AD-A045 409 AIR FORCE AERO PROPULSION LAB WRIGHT-PATTERSON AFB OHIO F/G 20/1
PROPELLER ACOUSTICS TEST FACILITY (CAPABILITY DESCRIPTION).(U)
AUG 77 P A SHAHADY, S W KIZIRNIS
UNCLASSIFIED AFAPL-TR-77-48 NL

1 OF 2
AD
A045409

AFAPL-TR-77-48

PROPELLER ACOUSTICS TEST FACILITY (Capability Description)

PAUL A. SHAHADY
SIGMUND W. KIZIRNIS
ROBERT M. McGREGOR, 2/LT, USAF

COMPONENTS BRANCH
TURBINE ENGINE DIVISION

AUGUST 1977

TECHNICAL REPORT AFAPL-TR-77-48
Final Report for Period 1 January 1970 through 31 October 1976

Approved for public release; distribution unlimited.

AIR FORCE AERO PROPULSION LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This report has been reviewed by the Information Office, ASD/OIP, and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Paul A. Shahady
PAUL A. SHAHADY, GS-13
Project Engineer

Sigmund W. Kizirnis
SIGMUND W. KIZIRNIS, GS-12
Project Engineer

Robert M. McGregor
ROBERT M. McGREGOR, 2Lt
Project Engineer

FOR THE COMMANDER

Robert E. Henderson
ROBERT E. HENDERSON, Tech Area Manager
Components Branch
Turbine Engine Division

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER 14 AFAPL-TR-77-48	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 PROPELLER ACOUSTICS TEST FACILITY (Capability Description).		5. TYPE OF REPORT & PERIOD COVERED Technical Report (Final) Jan 1970 through Oct 1976
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Paul A./Shahady, Sigmund W./Kizirnis Robert M./McGregor, 2/Lt		8. CONTRACT OR GRANT NUMBER(s) 16
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Aero-Propulsion Laboratory (AFAPL/TBC) Air Force Wright Aeronautical Laboratories Air Force Systems Command Wright-Patterson AFB OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 17 P.E. 62203F, Project 3066 Task 12 Work Unit 02
11. CONTROLLING OFFICE NAME AND ADDRESS Same as Block #9		12. REPORT DATE 11 Aug[redacted] 1977
		13. NUMBER OF PAGES 94
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 9 Final technical rept. 1 Jan 70-31 Oct 76,		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

12 100p.

Approved for public release; Distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Propeller Noise
Propeller Test
Propeller Acoustics
Acoustics Test

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the development of a research facility to investigate fan and propeller noise generation mechanisms. A 3500 horsepower electric whirl rig was modified to allow both near and far-field acoustic testing. The rig is located in a large building with acoustically-treated walls. Reverberation time and sound pressure level measurements were conducted to determine the acoustic characteristics of the building. Acoustic data is acquired using a portable analog FM multichannel tape recorder system. The resultant data is frequency analyzed in one-third octave or narrow bands. A series of data presentation programs have been developed to cross plot key performance and acoustic parameters.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

011 570

LB

FOREWORD

This report contains the description of a propeller acoustics test facility utilized to conduct a number of propeller performance and acoustic tests over the period from 1970 to 1976. The facility was developed by the Turbine Engine Division and the Technical Facilities Division of the Air Force Aero-Propulsion Laboratory, Wright-Patterson AFB, Ohio, under Project 3066, Task 12, Work Unit 02. The effort was conducted by Paul A. Shahady, AFAPL/TBC, and Sigmund W. Kizirnis, AFAPL/TFE during the period of 1 January 1970 to 31 October 1976. 2/Lt Robert M. McGregor provided major computer support to the project.

Special appreciation is extended to Raymond Allen for providing outstanding instrumentation support to the facility. Appreciation is also given to George Medisch, foreman of the facility test crew during most of the testing period, to Wellington Steel, William Howerton, Harold Crouch, Walt Stebel, and Harold Lee, members of the facility test crew and to Joseph Simmons for his support to the acoustic tests.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONT'D)

I. INTRODUCTION

The purpose of this report is to describe the development of a research facility to investigate fan and propeller noise generation mechanisms. Over the past several decades, a considerable amount of propeller noise experimental data has been obtained. Much of this data was acquired using simplified test rigs employing reciprocating or gas turbine engines as the means for driving the propeller. Noise from these drive systems seriously contaminated much of the measured propeller noise under certain operating conditions. The more recently constructed turbine engine fan test facilities have alleviated the drive noise contamination problem by properly suppressing drive system noise. However, most of the facilities capable of large-scale acoustic testing are located outdoors and are subject to weather conditions. Therefore, a program was initiated to develop an all-weather test capability to measure near- and far-field propeller and fan noise free of contamination from excessive background noise.

A 3500-horsepower electric whirl rig, located in Building 20A at Wright-Patterson AFB, was modified to allow both near- and far-field acoustic testing. The rig is located in a large building with acoustically treated walls. Reverberation time and sound pressure level measurements were conducted to determine the acoustic characteristics of the building. Acoustic data was acquired using a 12-channel portable data acquisition system consisting of microphone stands, microphones, land lines, signal conditioning equipment, a multi-channel analog FM tape recorder, and associated calibration equipment. Acoustic data is frequency analyzed into one-third octave or narrow bands and automatically plotted using a computerized dynamic analysis system located in the Air Force Flight Dynamics Laboratory at Wright-Patterson Air Force Base. A series of data presentation programs have been developed to cross plot a number of key performance and acoustic parameters.

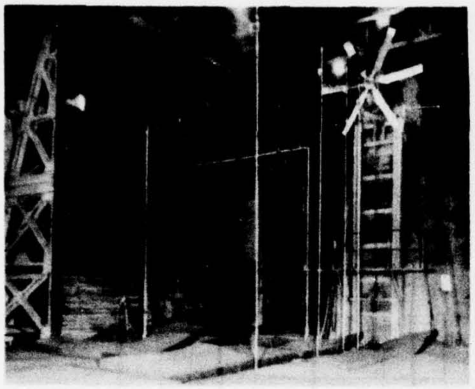
II. FACILITY DESCRIPTION AND PERFORMANCE MEASUREMENT SYSTEM

The 3500-horsepower electric whirl rig consists of a large concrete pier which houses the electric drive motor, thrust and RPM measuring equipment, and various accessory drives. The pier rises about 25 feet off the floor of a large open building. The facility side walls and floor were covered with six-inch thick Coustic TM polyurethane foam to minimize acoustic reflections. The control room is located under the pier and the propeller may be observed via a periscope and strobe light arrangement. Closed circuit TV cameras are also used to monitor the facility. Various parts of the facility are shown in Figure 1. The following technical summary of the performance measurement system is taken from Reference 1. The input power to the propeller is calculated from measuring the armature voltage and amperage at the electric drive motor. Predetermined correction factors are then applied to allow for the copper and field winding losses. The resultant watts are then converted to horsepower and an atmospheric correction factor is used to adjust the data to standard day conditions. These calculations are made with an electronic desk calculator during the course of the test so that field curves can be drawn to check for obvious data discrepancies. The system is calibrated against a well documented test propeller whose blades have been accurately set and locked into place. No-load losses are determined by motoring the rig at various RPM settings without a propeller attached.

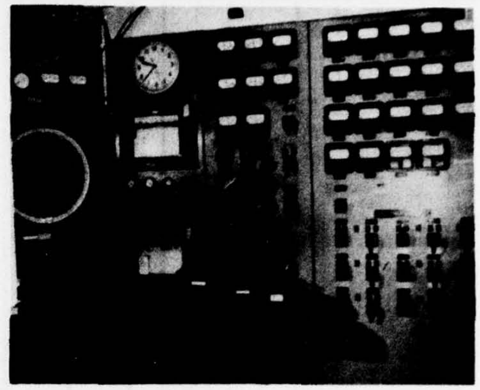
The thrust is measured by converting the movement of the propeller shaft to hydraulic pressure via a hydraulic diaphragm. The pressure signal is then directly converted to pounds thrust with a precalibrated Emery-Tate load indicator and then corrected to standard day conditions. The thrust system is calibrated statically by applying a known load (lead weights) to the propeller shaft. Accurate shaft RPM was obtained from a magnetic pickup which receives impulses from the drive motor shaft. These impulses are then presented on a digital display in the control room as propeller RPM.

All of the previously mentioned performance data, horsepower, thrust, and RPM, is taken directly from the instrumentation in the control room. This data is then corrected for the various loss and atmospheric effects by employing pre-determined correction factors. The data is tabulated on the form shown in Figure 2 and turned over to the project engineer for reduction. This is accomplished by using a computer program entitled "Computer Program for Reducing Static Propeller Test Data" (Reference 2). The following explanation of the program generally follows that of Chopin (Reference 3).

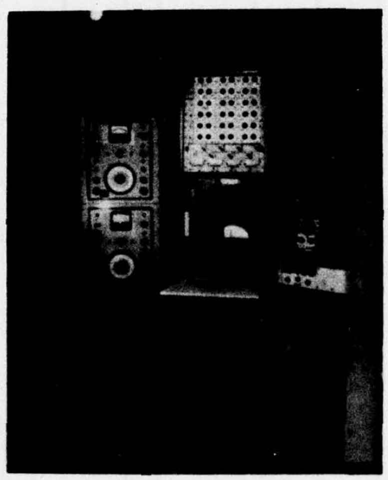
The program accepts whirl rig data in the format in which it is taken from the rig by the test crew. This is then reduced by the computer into power coefficients (C_p), thrust coefficients (C_t),



a) 3500 HP Whirl Rig



b) Performance Data Acquisition System



c) Acoustic Data Acquisition System

Figure 1: Propeller Acoustics Test Facility at Wright-Patterson AFB, Ohio

PROPELLER WHIRL TEST DATA SHEET

DATE 12-20-72	RIG 2	HUB DWG NO.	ENGINEER	TEMP $+3^{\circ}$
MFR	ADAPTER With Foam Rubber on	HUB SERIAL NO. 6 Blades Equal Spaced	CREW CHIEF	BAROMETER 29.16
PROJ NO. 30661208	BAFFLES Floor	BLADE DWG NO. Hi Tail Rotor Blades	TEST CREW Stebel	AIR FACTOR 1.0169
WHIRL TEST NO. 3026	T.T. 3.25	BLADE SERIAL NO.	Howerton	RIG FACTOR 1.006
SHEET NO. 7			Steele	TH FACTOR 1.023

ANGLE	10°											
RPM	601	752	900	1050	1201	1299	1402					
COR HP	26	37	56	85	121	152	189					
COR TH	188	298	430	601	786	928	1080					
ARM VOLTS	40	50	60	70	79	85	94					
MULTIPLIER	4	X20										
ARM AMPS	2.76	.6	.7	.83	.96	1.06	1.17					
MULTIPLIER	240	X600				X1200						
ARM WATTS	185	106	147	203	269	161	193					
CU LOSS						1	1					
F W I LOSS	34	47	61	76	92	103	118					
GEAR LOSS												
TOTAL HP	60	85	118	163	216	259	310					
TOTAL LOSS	34	47	61	76	92	104	118					
NET HP	26	38	57	87	124	155	192					
TH SCALE	193	305	440	615	805	950	1105					
BAL THRUST							0					
ACTUAL TH												
START	09:13											
STOP	09:45											
TEST TIME	:32											
START												
STOP												
RIG TIME												

REMARKS

Total Time 3 hrs. 57 min.
Blade Angle Checked 1. 9.9° 4. 10°
2. 9.9° 5. 9.9°
3. 10° 6. 10°

Figure 2: Performance Data Sheet

AFAPL FORM DEC 67 14a

C_t/C_p, figure of merit (F.M.), thrust/horsepower (Th/HP), and propeller tip Mach number. The output format of the program is shown in Table 1. The symbols presented in Table 1 are defined as follows:

PROPELLER CHARACTERISTICS

BETA	-	Test blade angle
AF	-	Blade activity factor
DIA	-	Propeller diameter in feet
NBL	-	Number of blades
TEMPC	-	Ambient temperature in degrees Centigrade
TEMPR	-	Ambient temperature in degrees Rankine
SIGMA	-	Density ratio

RAW DATA POINTS

RPM	-	Propeller rpm
HP	-	Corrected horsepower
TH	-	Corrected thrust
TMACH	-	Propeller tip Mach number
RCT	-	Raw thrust coefficient
RCP	-	Raw power coefficient
RCT/CP	-	Ratio of raw thrust to raw power coefficient
RFM	-	Raw figure of merit
RTH/HP	-	Ratio of raw corrected thrust to corrected horsepower

FITTED CURVE DATA FOR CONSTANT MACH NUMBER INCREMENTS

MACH	-	Selected Mach number increment
HP	-	Horsepower at Mach increment
TH	-	Thrust at Mach increment
TIPS	-	Propeller tip speed in ft/sec corresponding to Mach increment
RPM	-	Propeller rpm at Mach increment
CT	-	Thrust coefficient at Mach increment
CP	-	Power coefficient at Mach increment
CT/CP	-	Ratio of thrust coefficient to power coefficient at Mach increment
RM	-	Figure of merit at Mach increment
TH/HP	-	Ratio of thrust to horsepower at Mach increment

TABLE 1: PROPELLER PERFORMANCE DATA OUTPUT FORMAT

STATIC PROP PERFORMANCE

RUN___TITLE OF TEST

BETA=__ AF=__ DIA=__ NBL=__ TEMPC=__ TEMPR=__ SIGMA=____

* * * * * RAW DATA POINTS * * * * *

RPM	HP	TH	TMACH	RCT	RCP	RCT/CP	RFM	RTH/HP
__	__	__	__	__	__	__	__	__
__	__	__	__	__	__	__	__	__
__	__	__	__	__	__	__	__	__

* * * * * FITTED CURVE DATA FOR CONSTANT MACH NUMBER INCREMENTS * * * * *

MACH	HP	TH	TIPS	RPM	CT	CP	CT/CP	FM	TH/HP
__	__	__	__	__	__	__	__	__	__
__	__	__	__	__	__	__	__	__	__
__	__	__	__	__	__	__	__	__	__

III. ACOUSTIC DATA ACQUISITION SYSTEM

The acoustic data acquisition system consists of Bruel and Kjaer half-inch microphones and cathode followers and in-house designed line drive amplifiers mounted on portable microphone stands. The microphones are located 23 feet above the floor in a horizontal plane through the propeller centerline. A typical microphone array used for several test programs is shown in Figure 3.

The data signals are carried by 250-foot land lines to an instrumentation control room located below the rig. The signals were conditioned through variable gain amplifiers and recorded on a 14-channel AMPEX FR 1300 tape unit for later analysis. A data flow schematic of the acoustic data acquisition system is shown in Figure 4. The two symbols for the tape recorder represent the data flow in the record mode and in the reproduce mode respectively. Gain and attenuator adjustments are accessible at various points in the system. Phase and gain controls are located at the line drive amplifier for system calibration adjustments. A zero to twenty dB attenuation is available at the junction box. Final adjustments are made at the variable gain amplifiers before the signals are input to the tape recorder. The data signals can be monitored at various points in the system. A signal output BNC is located at the line drive amplifier and at the junction box. Individual channel scopes are used to monitor either the tape recorder input signals or the reproduced output signals. A signal selector circuit is used to provide any of the tape recorder input signals for detailed analysis. These signals are recorded on the loop recorder for on-line frequency analysis. These various monitor outputs allow the signal to be evaluated on the output side of each major component from the line drive amplifier to the tape recorder. The total system is calibrated at the beginning and end of each tape and at the beginning and end of each test day. An NBS traceable piston phone provides a 124 dB pressure signal at 250 Hertz to the microphone diaphragm. This signal is recorded on tape for each microphone channel. Gains for the various data acquisition system components are recorded manually on data log sheets.

The data acquisition system is primarily comprised of off-the-shelf general purpose instrumentation. However, four of the components, the line drive amplifier, junction box, signal selector, and audio monitor system were designed in-house. Detailed schematics of these components are presented in Appendix A.

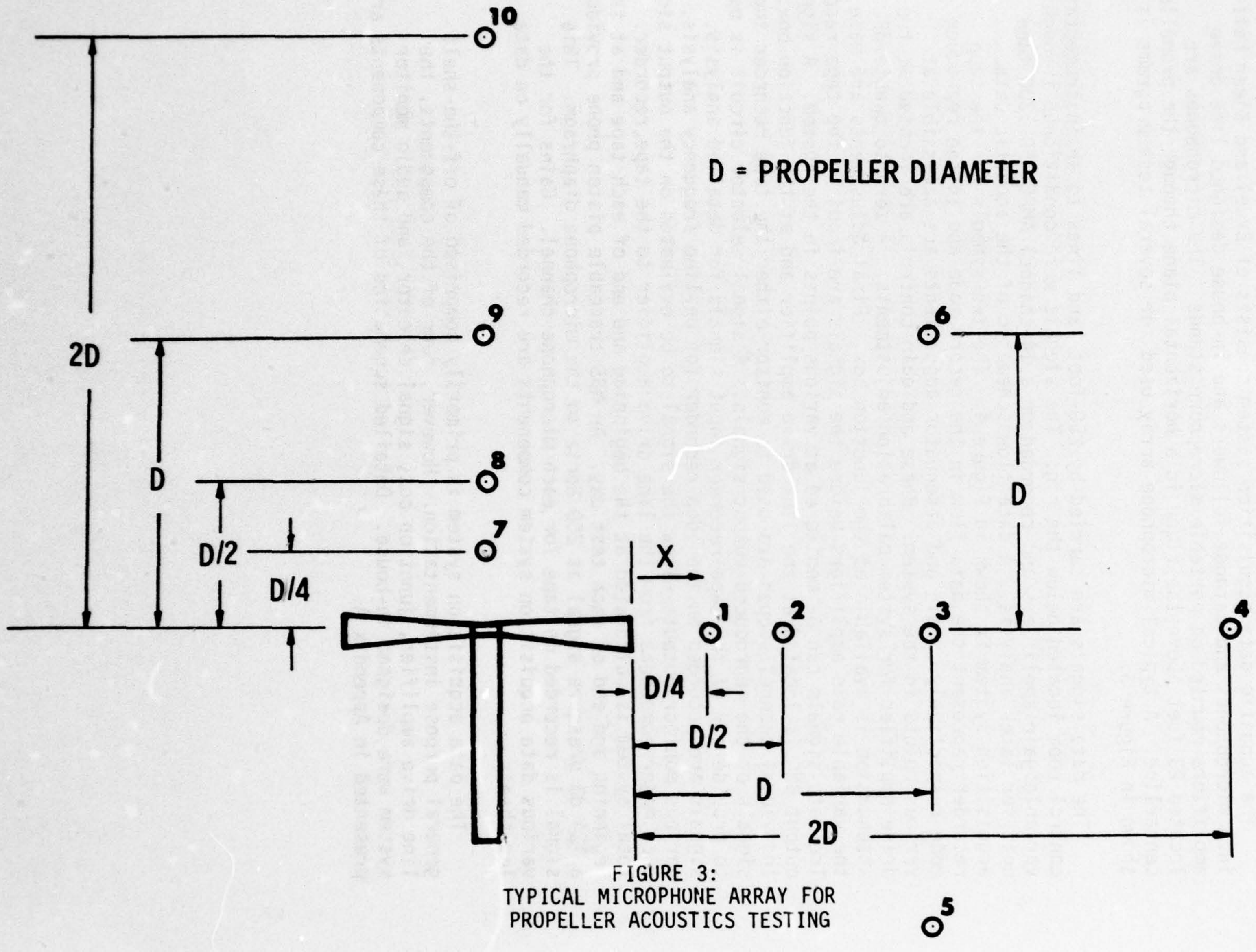


FIGURE 3:
TYPICAL MICROPHONE ARRAY FOR
PROPELLER ACOUSTICS TESTING

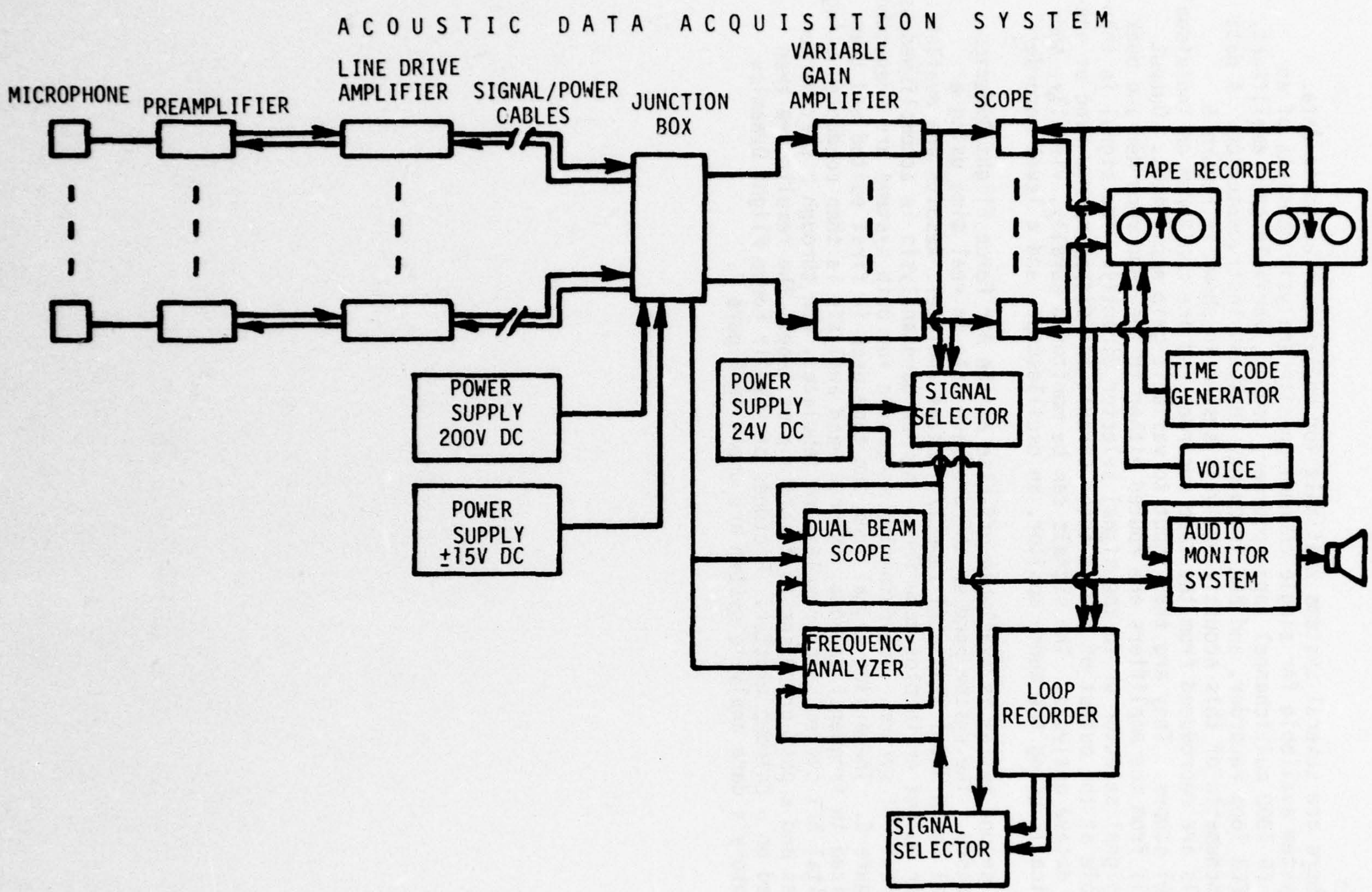


FIGURE 4: DATA FLOW SCHEMATIC FOR ACOUSTIC DATA ACQUISITION

IV. ACOUSTIC DATA ANALYSIS SYSTEM

There are several systems available for analysis of acoustic data. One system available for single channel on-site analysis consists of an AMPEX FR 1300 multichannel tape recorder, scopes, variable gain amplifiers, an AMPEX loop recorder, and B&K frequency analysis instrumentation. A data flow schematic of this acoustic analysis system is shown in Figure 5. Signals are reproduced from the tape recorder and are monitored on individual channel scopes. They are then input to variable gain amplifiers. Output signals from the amplifiers are routed either to the loop recorder and back to a signal selector or to the signal selector directly. The signal is then available at the output of the selector circuit for either narrow band or one-third octave analysis. The signals can be monitored aurally, visually, and graphically using the audio monitor, an oscilloscope, and a level recorder.

A second system is available off-site at the Air Force Flight Dynamics Laboratory. The system handles third-octave data in real time using a General Radio Model 1933 real time 1/3 octave analyzer. Results are available in tabular output or in plot tape form. Narrow band analysis is accomplished using a digital FFT system. The data flow schematic for both systems are presented in Figure 6. The analog signal from the tape deck is first edited and then digitized in frequency decades. Narrow band analysis is then conducted using a digital FFT system. The results are tabulated, run through a sort/merge process and a post processor to create a plot tape. The results are then plotted on a calcomp plotter. Pictures of the Air Force Flight Dynamics Laboratory's data analysis system are shown in Figure 7.

A C O U S T I C   D A T A   A N A L Y S I S   S Y S T E M

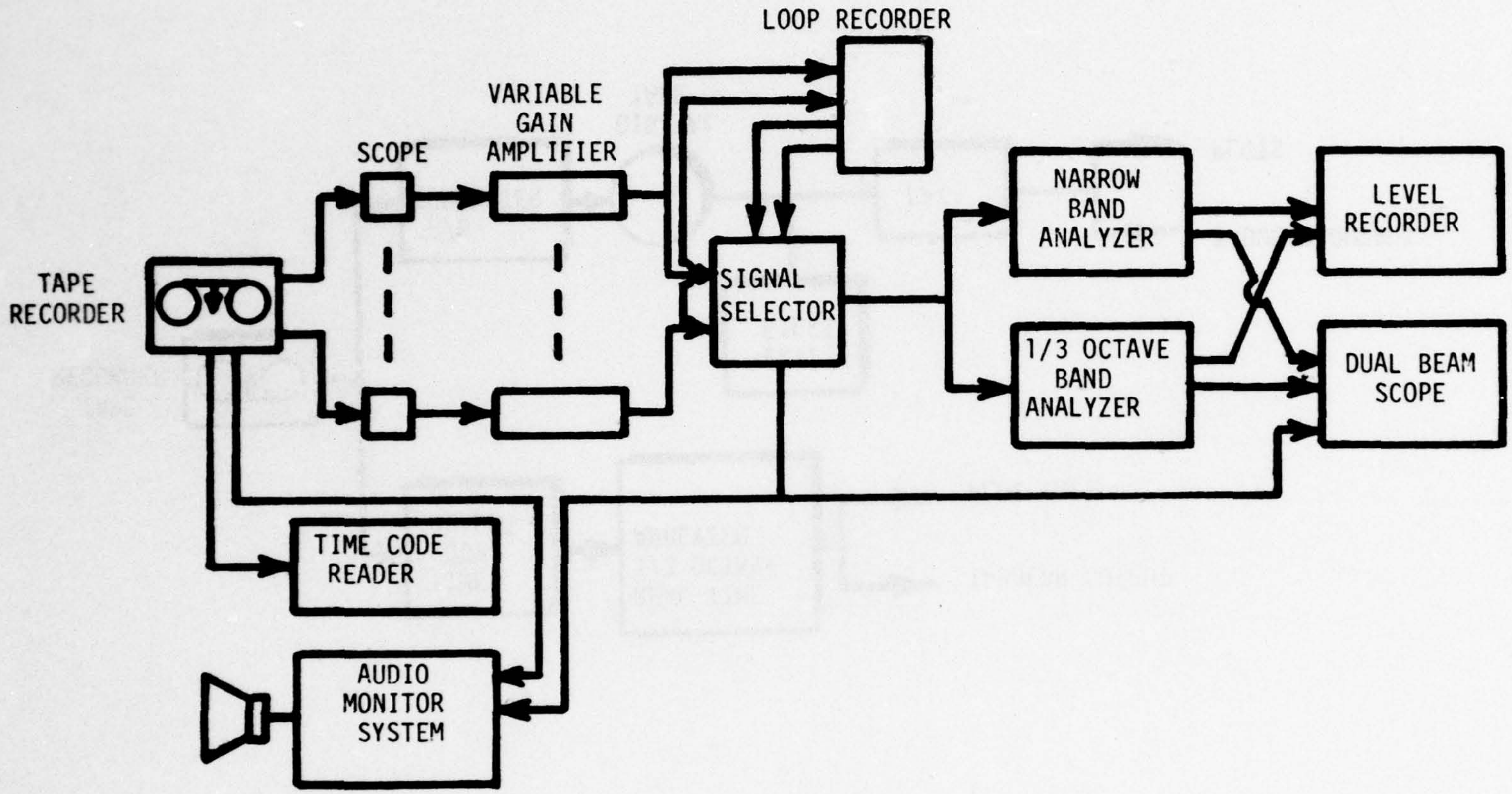


FIGURE 5: DATA FLOW SCHEMATIC FOR ON-LINE ACOUSTIC DATA ANALYSIS

ACOUSTIC DATA ANALYSIS SYSTEM

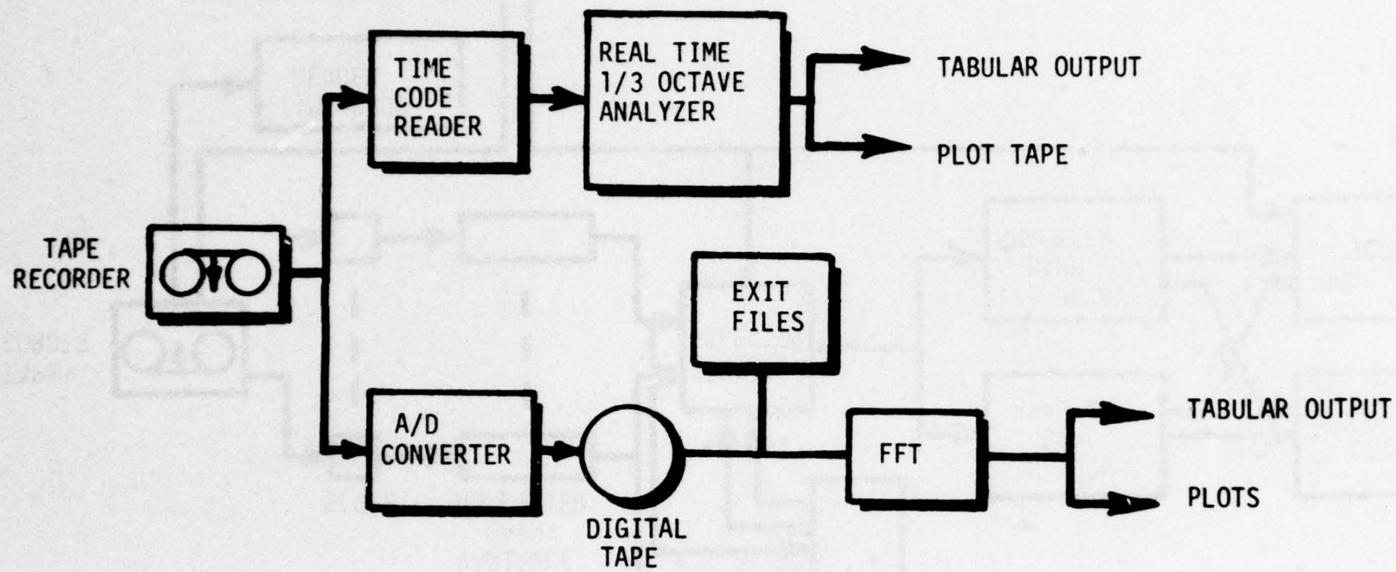
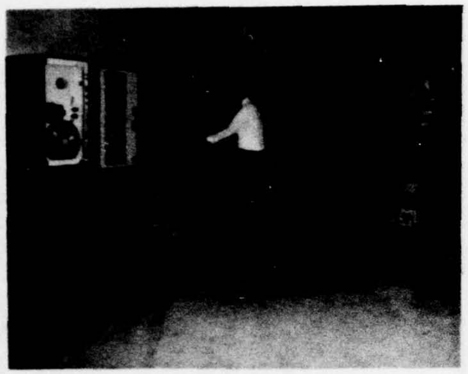


FIGURE 6: DATA FLOW SCHEMATIC FOR OFF-LINE ACOUSTIC DATA ANALYSIS



a) *Data Recovery and Editing*

b) *Analog-to-Digital Conversion*

c) Digital Analysis

d) Data Presentation

Figure 7: Dynamic Data Analysis System at the Flight Dynamics Laboratory

V. ACOUSTIC DATA PRESENTATION SYSTEM

Several computer programs were written to reduce and plot propeller performance and acoustic test data. The data comes in two basic forms: Propeller Whirl Test Data Sheets (AFAPL Form 14A), and digitized sound spectra computer cards.

Data from the test rig sheets must first be coded onto computer cards as shown in Figure 8. In this format it is compatible with programs written for data reduction programs in ASD-TR-68-19, "Computer Program for Reducing Static Propeller Test Data." Not all data on these cards will be required by each individual program, but with commonality, the number of cards and the time spent punching them is reduced.

The digitized spectra data cards were obtained from a General Radio 1933 Real Time third-octave band analyzer, and come in two formats. The first format covers the frequencies from 3.15 Hz through 20,000 Hz, while the second covers 20 Hz through 20,000 Hz. Each block of data consists of four cards, the first containing the run and microphone channel identification numbers. The last number on the last card is the overall sound pressure level (OASPL) in dB for that block. All other numbers represent the SPL's for their respective third-octave bands. Figure 8.a. shows data sets for three microphones (4, 5, 6) during run number six of a particular configuration.

The basic coded rig data and spectra data are used by five programs: HORSE, THORSE, NOISY1, NOISY2, and DBA. Each program is written in FORTRAN IV-Extended for the CDC 6600 computer, and with the exception of DBA, requires a CALCOMP plotter and associated software. DBA requires a peripheral card punch. References 2 and 4 were used in the development of these programs.

HORSE

Program HORSE plots thrust vs. horsepower for any configuration. Several parameters which control the output format have been preset within the main program body. Changes should be made using a NAMELIST card. Input may include 600, 750, 900, 1050, and 1200 RPM data or 600, 900, and 1200 RPM data. If five points are entered, all five will be used. Likewise, if three are entered, three will be plotted. Setting the Namelist variable IORPM = 2 gives three-point output even if five points are entered. Three blade angles are required for each RPM. Spline-fitted curves through all points are standard. Thrust and horsepower limits are preset at 1600 and 240 respectively, and are held constant for easy comparison between plots. If desired, the user may specify his own limits. Different limits need only be set once for any number of plots generated during a single program run. If changes are required, however, 99999 in columns 1 - 5 alerts the program to a new $INPUT card. A program listing with sample input cards and output plots is found in Appendix B.1.

PROPELLER WHIRL TEST DATA SHEET

DATE 12-20-72	RIG 2	HUB DWG NO.	ENGINEER	TEMP +3°
WFR	ADAPTER With Foam Rubber on	HUB SERIAL NO. 6 Blades Equal Spaced	CREW CHIEF	BAROMETER 29.16
PROJ NO. 30661208	BAFFLES Floor	BLADE DWG NO. Hi Tail Rotor Blades	TEST CREW Stebel	AIR FACTOR 1.0169
WHRL TEST NO. 3026	T.T. 3.25	BLADE SERIAL NO.	Howerton	RIG FACTOR 1.006
SHEET NO. 7			Steele	TH FACTOR 1.023

ANGLE	10°											
RPM	601	752	900	1050	1201	1299	1402					
COR HP	26	37	56	85	121	152	189					
COR TH	188	298	430	601	786	928	1080					
ARM VOLTS	40	50	60	70	79	85	94					
MULTIPLIER	4	X20										
ARM AMPS	2.76	.6	.7	.83	.96	1.06	1.17					
MULTIPLIER	240	X600				X1200						
ARM WATTS	185	106	147	203	269	161	193					
CU LOSS						1	1					
F W L LOSS	34	47	61	76	92	103	118					
GEAR LOSS												
TOTAL HP	60	85	118	163	216	259	310					
TOTAL LOSS	34	47	61	76	92	104	118					
NET HP	26	38	57	87	124	155	192					
TH SCALE	193	305	440	615	805	950	1105					
BAL THRUST							0					
ACTUAL TH												
START	09:13											
STOP	09:45											
TEST TIME	:32											
START												
STOP												
RIG TIME												

REMARKS

Total Time 3 hrs. 57 min.
Blade Angle Checked 1. 9.9° 4. 10°
2. 9.9° 5. 9.9°
3. 10° 6. 10°

A Number of Blades
B Blade Pitch Angle
C Temperature (°C)
D Air Factor
E Propellor RPM
F Horsepower
G Thrust

AFAPL FORM DEC 67 14a

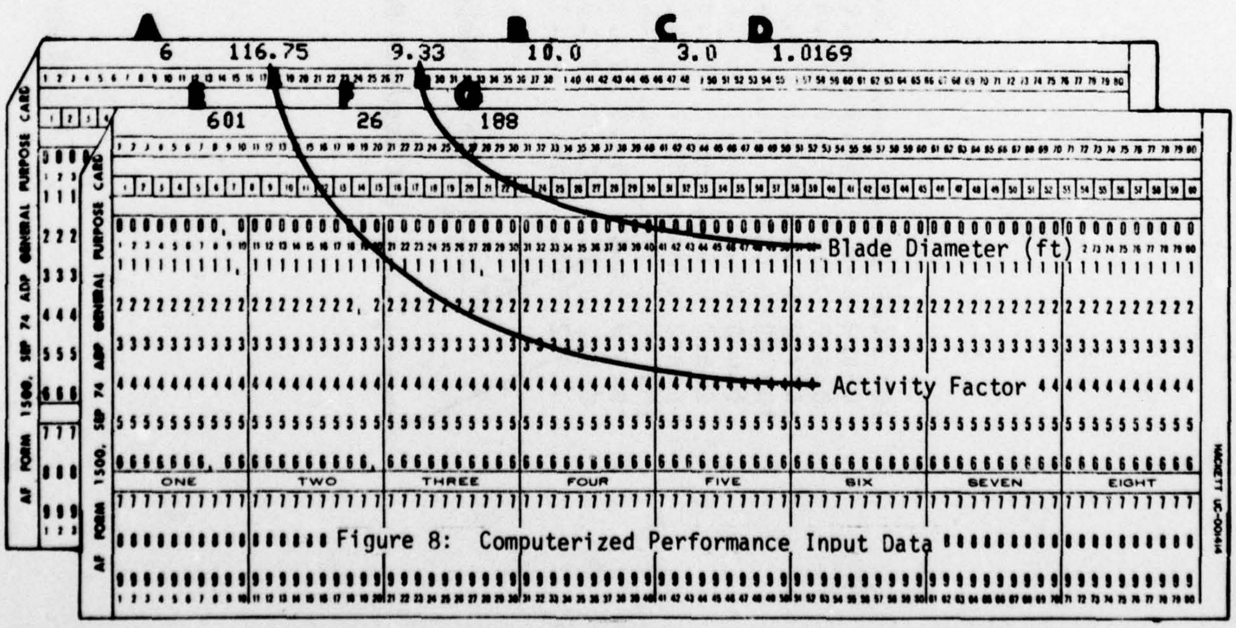


Figure 8: Computerized Performance Input Data

```
ID: R006 C004$ 034.0 034.0 034.0 034.0 034.0 034.0 034.0 034.0 037.2 040.2
 050.2 043.0 046.7 054.0 043.0 044.5 051.5 049.5 053.5 057.7
 060.2 061.2 059.0 061.0 059.5 060.5 059.0 058.0 059.5 068.5
 077.7 081.5 076.5 066.2 062.0 058.0 034.0 034.0 034.0 083.5
ID: R006 C005$ 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0
 044.0 044.0 049.7 059.7 047.0 056.5 063.0 061.5 064.5 066.0
 066.7 068.5 069.0 069.0 069.5 068.7 069.0 068.0 070.0 079.7
 086.2 089.5 083.7 074.2 070.2 065.7 044.0 044.0 044.0 091.5
ID: R006 C006$ 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.7
 049.[illegible] 044.7 059.5 072.0 051.2 057.2 063.2 063.2 066.7 068.0
 069.0 07[illegible].5 071.0 072.0 071.5 071.2 072.0 070.7 072.5 079.7
 08[illegible].2 0[illegible]2.0 085.5 077.0 074.0 067.7 044.0 044.0 044.0 093.7
```

Microphone Number

Test Sequence Number

Overall SPL (dB)

FIGURE 8a: BASIC DIGITIZED 1/3-OCTAVE SPL DATA

THORSE

Program THORSE is a derivative of HORSE, and plots the ratio of thrust to horsepower versus horsepower. Input cards are exactly the same as those for HORSE. Any section of a plot which falls below the X-axis is automatically eliminated. This is not true for values exceeding the Y-axis maximum (preset at 11.) where the user risks running the plotter into the travel stops, and throwing all remaining points out of place. A program listing with sample input cards and output plots is found in Appendix B.2.

NOISY1

Program NOISY1 plots SPL (dB) versus third-octave band frequency. The user may select any range between 20 Hz and 10,000 Hz for plotting. The overall SPL for the selected range is plotted separately on the right of the graph. The user may elect to have the A-weighted spectra plotted along with the dB spectra. Any number of spectra may be put on the same axes as long as they are from the same microphone channel. As in the previous programs, plotting parameters are preset but may be changed using the standard NAMELIST format. A blank card at the end of a block of data signals an end to plotting on that set of axes. The user then has three options: (1) end that session of plotting with an ENDDATA card, (2) start another plot with a new set of data cards or, (3) change the output Namelist parameters using a NEWPARAM card. Following the NEWPARAM card should be a new set of data. The program listing, sample input cards and output plots are found in Appendix B.3.

NOISY2

Program NOISY2 is a derivative of NOISY1. NOISY2 plots the spectra of several microphones on the same axes as long as the RPM remains constant. This differs from NOISY1 where the RPM varied for a single microphone. A program listing with sample input cards and output plots is found in Appendix B.4.

DBA

Program DBA reduces the digitized spectra data to dB and dBA sound pressure levels. The program sorts through each run of the basic data, stopping at user-specified microphone numbers. Over any given spectra range, the program will then calculate the overall SPL in both dB and dBA. The data are then punched on cards with the corresponding identification numbers and calculation range indices. If cards are not desired, the user may set IPUNCH = 0 and receive only the printput. Punched cards from DBA are used by program NEWCITY. A program listing with sample input cards and an output listing are found in Appendix B.5.

NEWCITY

The final data presentation program is NEWCITY. Using both the basic rig data and the SPL data cards from DBA, NEWCITY will plot SPL vs. thrust and SPL vs. horsepower. Several options for presentation are open to the user. The user may elect to receive either the thrust or horsepower

plots or both. The legend block may be eliminated. Three or five RPM values may be used, depending on the input data. Output curves may be in either dB or dBA, with spline or up to 6th-order polynomial-fitted curves. If the number of points is too few for the requested polynomial fit, NEWCITY will default to the highest possible polynomial. A program listing with sample input cards and an output listing are found in Appendix B.6.

VI. FACILITY ACOUSTIC CHARACTERISTICS

Ideally, we would like to be able to measure noise characteristics in a free-field environment uncontaminated by acoustic reflections, room mode interactions, reverberation, background noise, etc. Unfortunately, we are faced with all these problems when we attempt to evaluate acoustic sources in an enclosure. We must, therefore, either minimize these problems or carefully define their effect on the acoustic characteristics of the source.

Acoustic Reflections

The problem of acoustic reflections contaminating data measured on propeller whirl rig #2 has been minimized by the use of high absorption acoustic treatment on the near walls and the floor of the test rig. Six-inch thick pads of Custifoam were used to eliminate all reflections above five hundred Hertz and minimize reflections in the 100 to 500 Hertz range.

Room Mode Interactions

The acoustic power output of a source depends on the impedance presented to it by the surrounding medium. Reverberant room modes may increase or decrease this impedance depending on the location of the source and on its frequency relative to the room mode frequencies. If the room is very large in comparison with the acoustic wavelength, there will be so many modes at any given frequency that the effects of the individual modes are likely to cancel out. The total number of room resonances occurring in a rectangular room in the frequency range from 0 to f is given by the expression.

$$Q = \frac{4\pi V}{3} \times \left(\frac{f}{c}\right)^3 + \frac{\pi S}{4} \times \left(\frac{f}{c}\right)^2 + \frac{L}{2} \times \left(\frac{f}{c}\right) \qquad (1)$$

Where: $V \equiv$ room volume (m^3)

$S \equiv$ room surface (m^2)

$L \equiv$ room edges, $l_x + l_y + l_z$ (m)

$c \equiv$ velocity of sound (m/sec)

In a narrow frequency band ($\Delta f = f_2 - f_1$) around f the number of resonances are

$$\Delta Q = Q_{f_2} - Q_{f_1} \qquad (2)$$

For Building 20A, $V = 69{,}859\ m^3$, $S = 13{,}012\ m^2$ and $L = 170$ m

Figure 9 gives the number of room resonances for the propeller test facility for one-third octave bands at octave band center frequencies from 63 Hertz to 8 KHz. Figure 10 shows the uncertainty of the power output at a single arbitrary source position for a simple source for both pure tones and bands of noise. This shows that the expected error can be neglected if the room is large enough assuming that the source is more than a wavelength from a wall (Reference 5). For the propeller rigs, the near walls and the floor adversely affect the data below 60 Hertz.

Reverberation

The reverberation characteristics of the facility were evaluated using the Norris-Eyring Formula (Reference 6) where the reverberation time in seconds is given by the expression

$$T = \frac{0.161V}{S[-2.3 \log_{10}(1-\bar{\alpha})]} \qquad (3)$$

Where: $V \equiv$ volume of room, m^3

$S \equiv$ area of bounding surface, m^2

$\bar{\alpha} \equiv$ average absorption coefficient of the room

The average absorption coefficient is therefore given by

$$\bar{\alpha} = 1 - 10^{-.07V/ST} \qquad (4)$$

The room constant, R_T, is given by the expression

$$R_T = \frac{S\bar{\alpha}}{1-\bar{\alpha}} \qquad (5)$$

Reverberation time measurements were made in the facility using a rifle as the sound source. A number of shots were recorded on magnetic tape at various locations in the facility. The data was then analyzed in one-third octave frequency bands at octave band center frequencies. Plots of amplitude versus time for these bands were used to determine the reverberation time. The reverberation time, average absorption coefficient, and room constant are given as a function of third-octave bands at octave band center frequencies in Table 2. Figure 11 gives the relative sound pressure level as a function of distance from the acoustic center of a non-directional source for Building 20A. Relative sound pressure level is given by the expression

$$SPL-PWL = 10 \log_{10} \left(\frac{Q}{4\pi r^2} + \frac{4}{R_T}\right) \qquad (6)$$

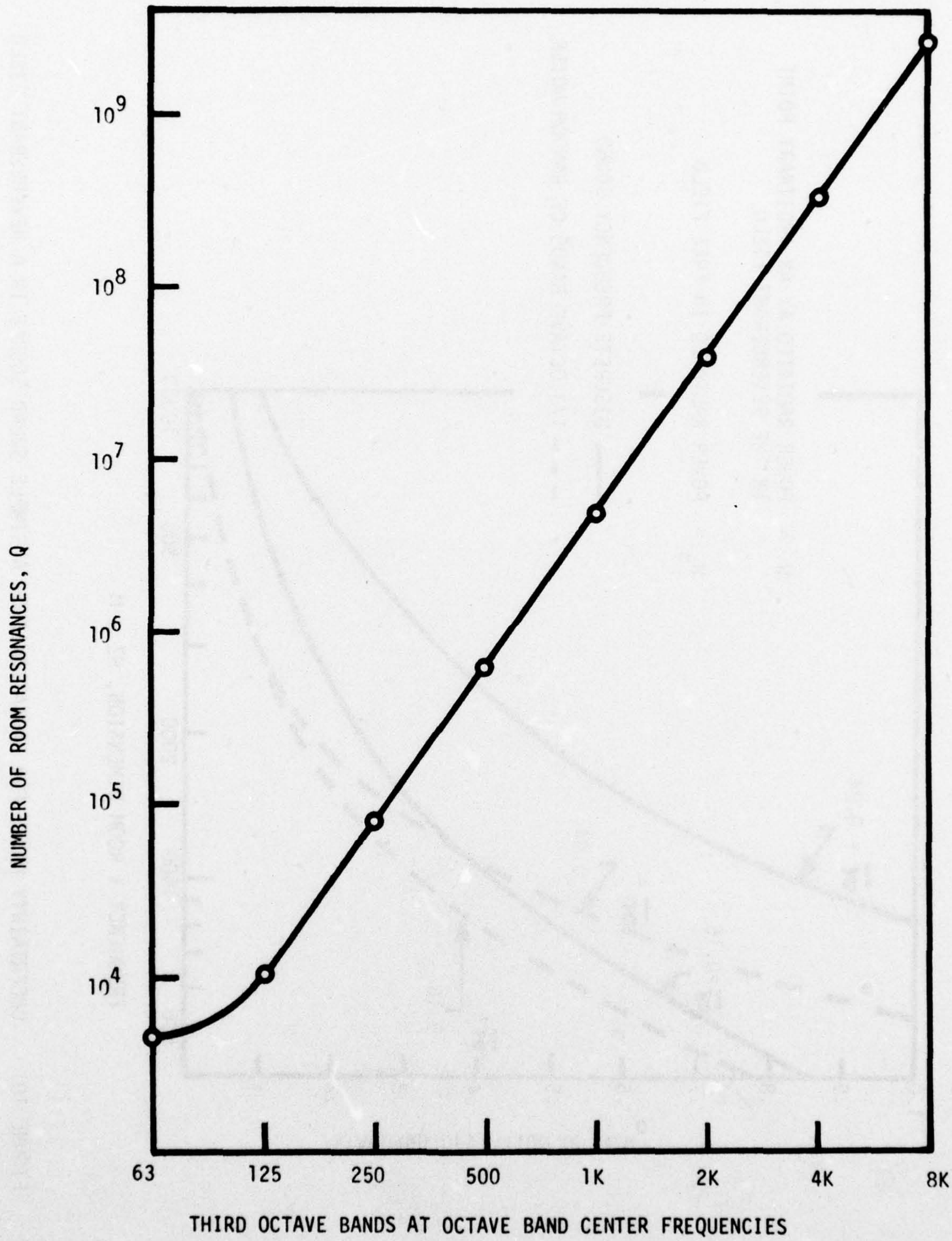


FIGURE 9: ROOM RESONANCES IN THIRD OCTAVE BANDS AROUND OCTAVE BAND CENTER FREQUENCIES

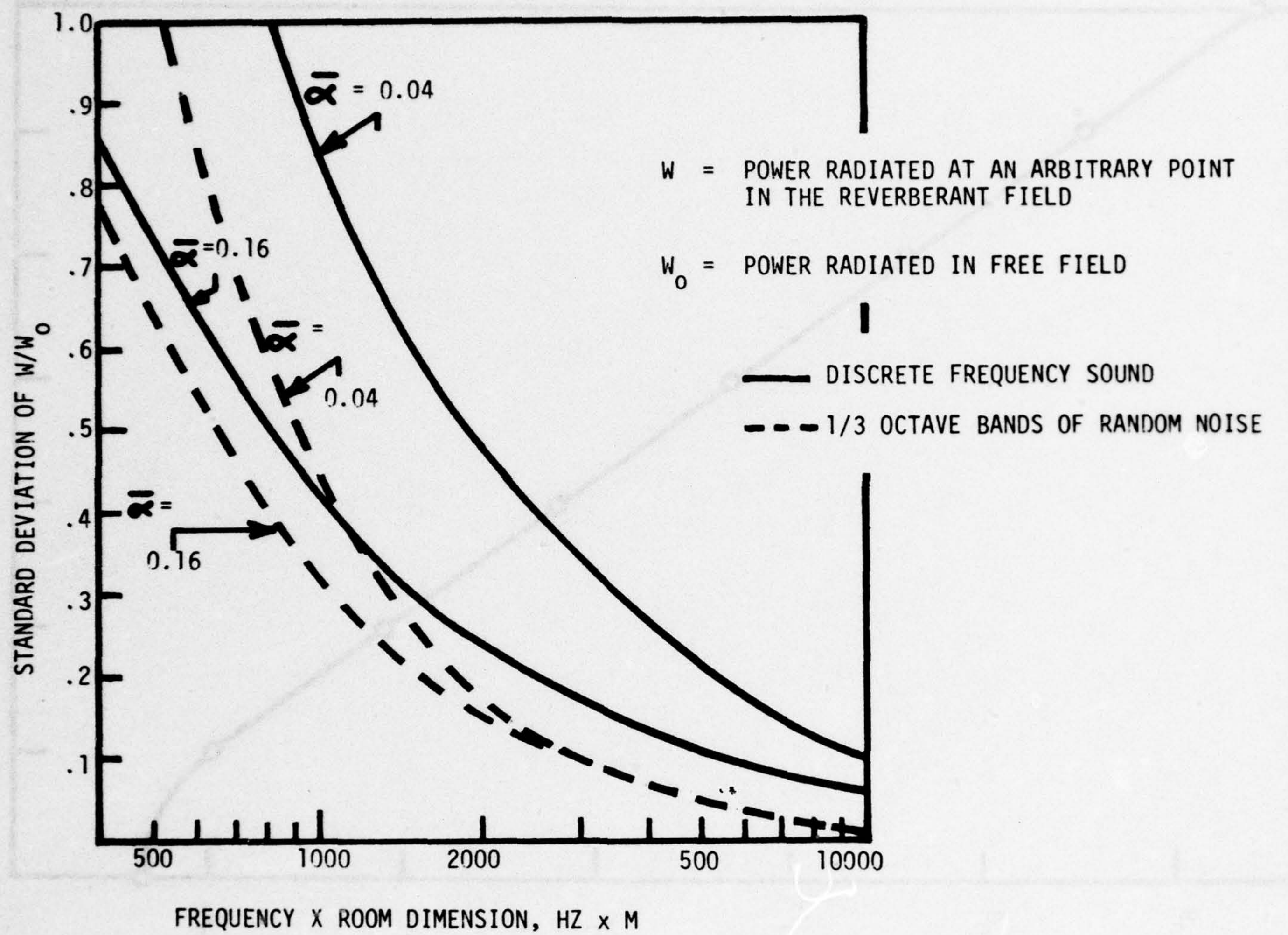


FIGURE 10: UNCERTAINTY RANGE FOR RADIATION FROM A SIMPLE SOUND SOURCE IN A REVERBERANT FIELD

TABLE 2: Reverberation Time, Average Absorption Coefficients, and Room Constants in Octave Bands for Building 20A

		OCTAVE BAND CENTER FREQUENCIES - HERTZ							
	OVERALL	63	125	250	500	1K	2K	4K	8K
T(sec)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.3	1.8
$\bar{\alpha}$	.42	.42	.42	.42	.42	.42	.42	.49	.66
$R(m^2)$	9336	9336	9336	9336	9336	9336	9336	12306	25369

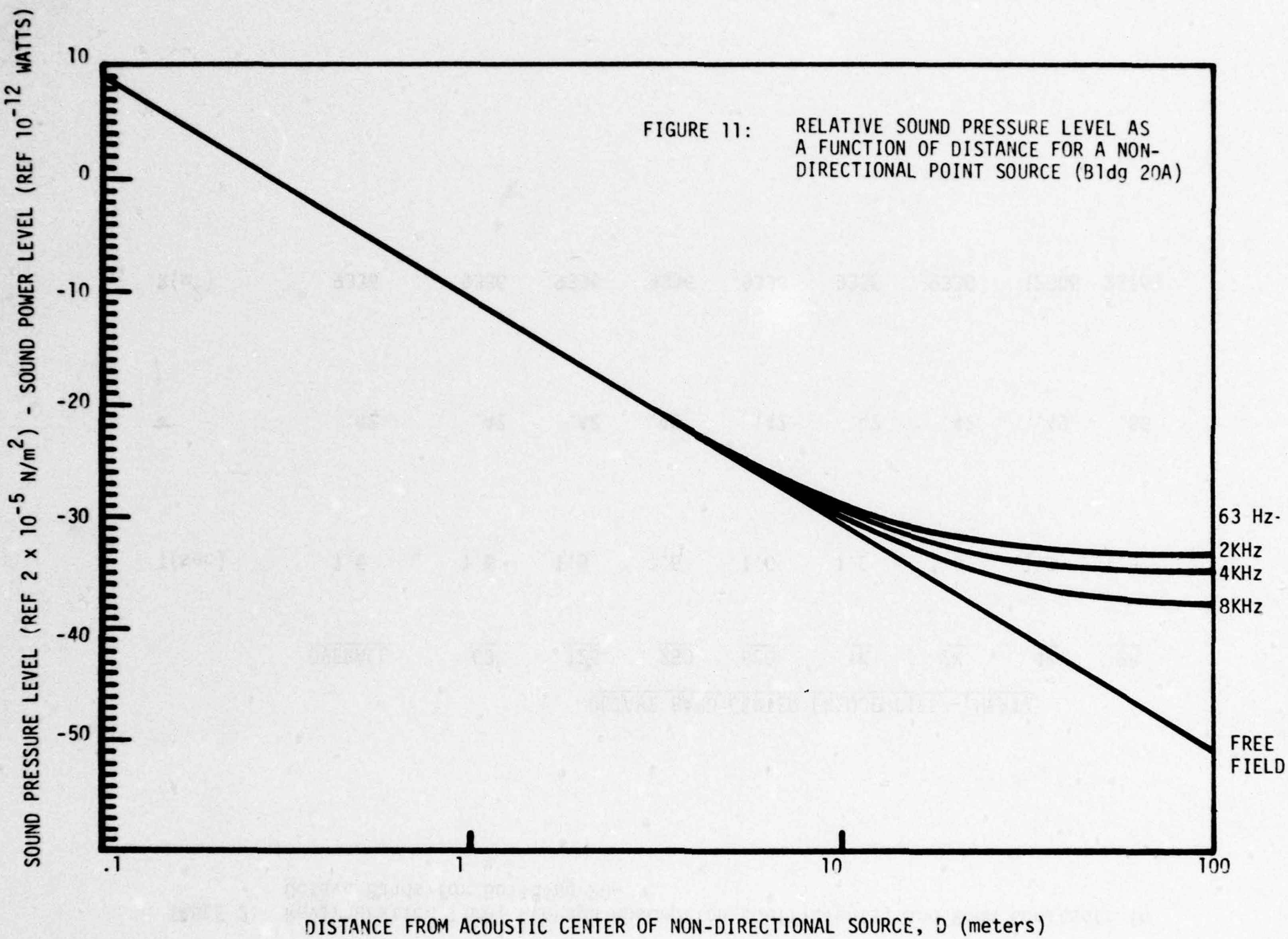


FIGURE 11: RELATIVE SOUND PRESSURE LEVEL AS A FUNCTION OF DISTANCE FOR A NON-DIRECTIONAL POINT SOURCE (Bldg 20A)

Where: R_T is the room constant in m^2

r is the distance in m

Q is a directivity factor (equal to 1 for propeller test rigs)

Since the room constants for Building 20A are the same for all frequency bands between 63 Hertz and 2 KHz, this range is represented by the top curve in Figure 11. The straight line shows the variation of relative sound pressure level with distance for a free-field environment (no reflections, reverberations, etc.).

Background Noise

Background noise during testing in the Building 20A facility is not a significant problem. Figure 12 shows a plot of background noise without the facility drive motors operating. Figure 13 shows the background noise as a function of RPM for a rotating propeller hub without blades. Neither case results in significant background noise when compared to the noise generated by a typical propeller. The measurements were made at a typical microphone position approximately 3 meters from the source. During each propeller test program, ambient and drive motor background levels are recorded as a function of RPM for each microphone position. In this way the source noise levels can be compared directly with the background noise to ensure that the signal-to-noise ratio is adequate. Generally, we require that the signal be at least 10 dB above the background noise in each third-octave band of interest.

We have now evaluated several problem areas relative to acoustic testing in Building 20A--acoustic reflections, room mode interactions, reverberation, and background noise. One other area should be investigated to properly understand the acoustic data obtained during propeller testing. Since acoustic propagation characteristics with distance change depending on the source, we should know what to expect in terms of noise level variation with distance from the propeller. It is beyond the scope of this report to discuss all of the noise generation and propagation theories applicable to propellers. An excellent review of propeller noise theory is contained in Reference 7. It is sufficient to point out that the broadband characteristics of a propeller can best be evaluated from noise measurements made along the axis of the propeller. Along the axis there is no Doppler effect. Also, the acoustic spectrum measured on the axis is generated entirely by fluctuating loads on the blade and is simply related to their integrated spectrum. Measurements made in the plane of rotation involve predominantly rotational noise due to harmonics of the blade passage frequency.

Reference 8 provides the basis for a preliminary analysis of noise propagation with distance from a propeller. In our application, we use a slightly modified version of Maekawa's result for circular plane noise

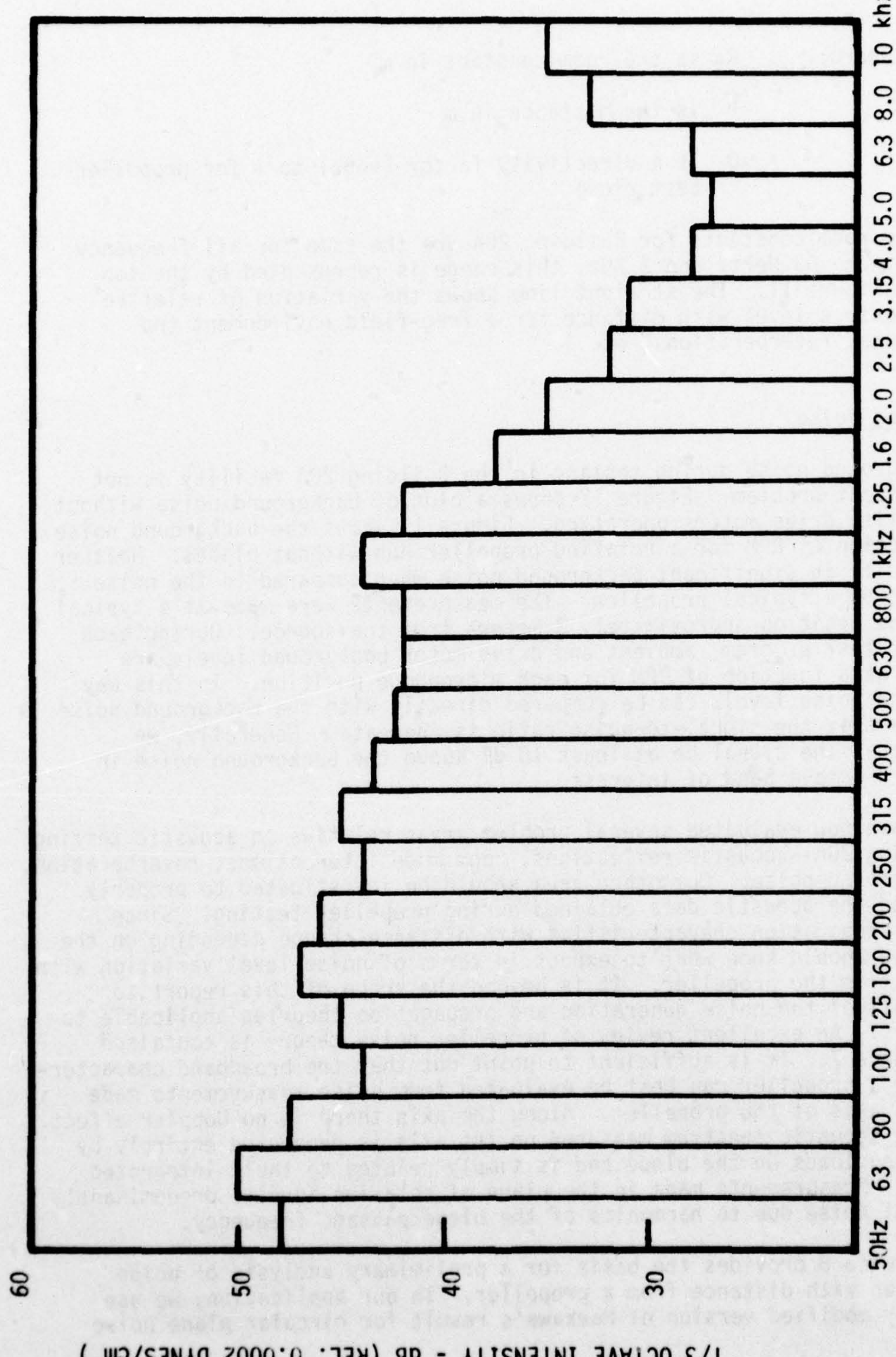


FIGURE 12: BUILDING 20A AMBIENT NOISE LEVELS

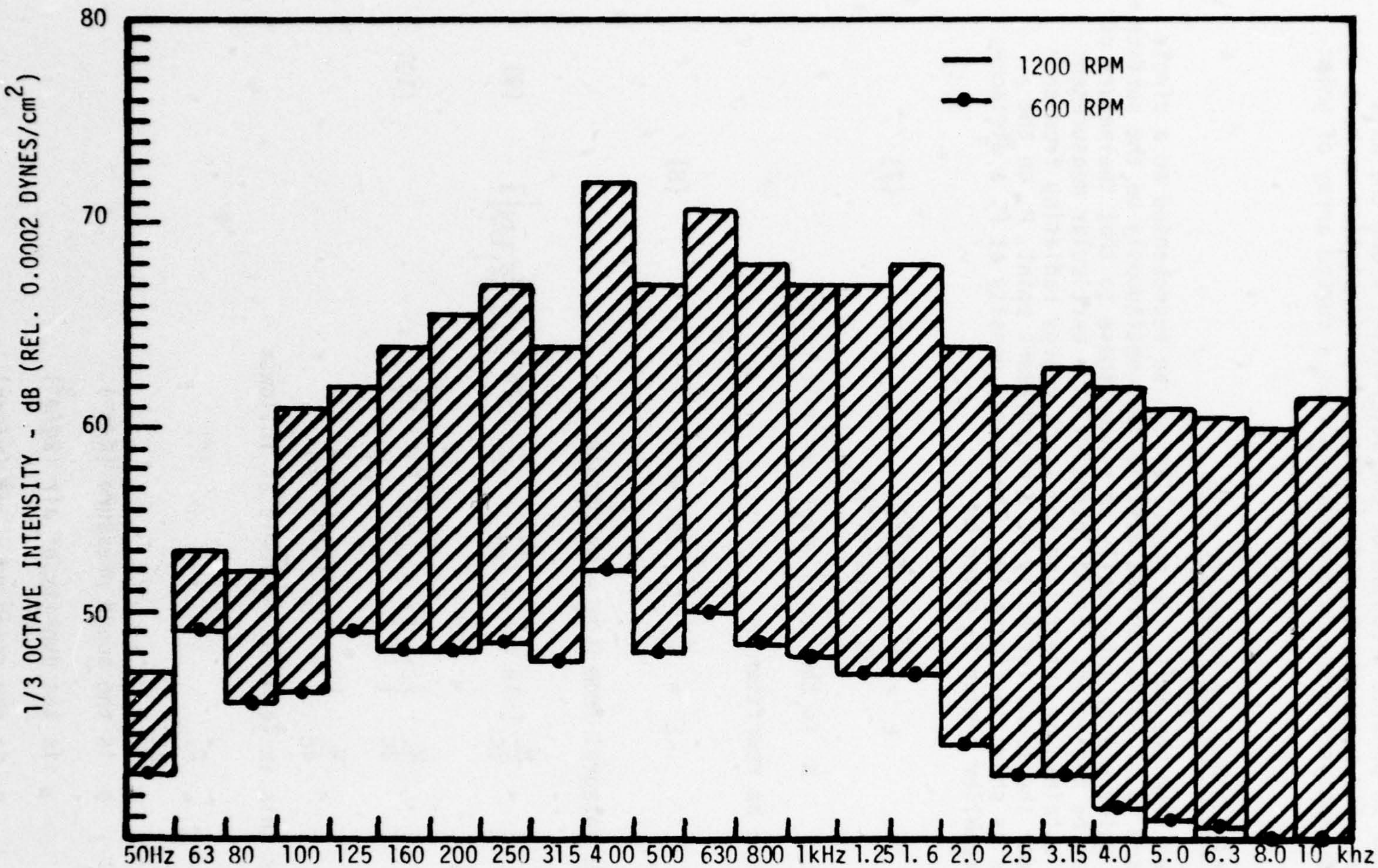


FIGURE 13: RIG #2 BACKGROUND NOISE FOR DRIVE MOTOR AND PROPELLER HUB WITHOUT BLADES

sources in order to predict propagation characteristics along the axis of a propeller. For measurements made in the plane of rotation we have developed a new analysis based on propagation from a curved array of point sources.

Noise Propagation Along the Propeller Axis

When viewed from the axis, the propeller can be represented as a circle of radius R made up of point sources distributed continuously on the surface and radiating noise energy spherically in random phase so that the nature of wave motion can be neglected. Sound intensity at a particular measurement point will be obtained by integrating the sound energy radiating from each point. Consider the sound intensity at a measurement point, P, on the propeller axis as shown in Figure 14. The energy density at P, a distance, d, from the propeller center is given by

$$E = \int_S \frac{W\,dS}{4\pi(d^2+x^2)c} \tag{7}$$

Where: W is the sound power per unit area

Equation (7) can be rewritten as

$$E = \frac{W}{2c}\int_0^{\infty} \tan\theta\, d\theta \tag{8}$$

Evaluating the integral from 0 to ∝ we obtain

$$E = \frac{W}{2c}\left[-\ln\cos\theta \,\Big|_0^{\infty}\right] = \frac{W}{2c}\left[-\ln\left|\frac{d}{(R^2+d^2)^{1/2}}\right|\right] \tag{9}$$

$$E = \frac{W}{2c}\left\{-\ln\left[1+(d/R)^{-2}\right]^{-1/2}\right\} \tag{10}$$

$$E = \frac{W}{4c}\left\{\ln\left[1+(d/R)^{-2}\right]\right\}$$

We can express this in terms of decibels as follows:

$$E = \frac{p^2}{\rho c^2}$$

Where: p is the sound pressure (N/m^2)

ρ is the density of air (kg/m^3)

c is the speed of sound (m/sec)

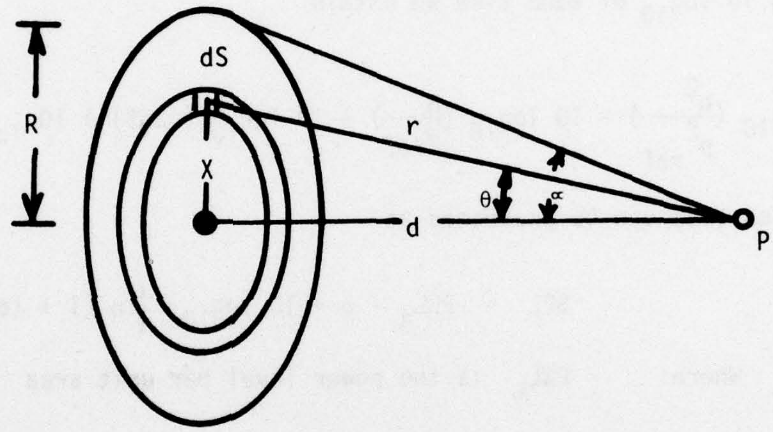


FIGURE 14: GEOMETRY FOR A PROPELLER AS VIEWED FROM A MEASUREMENT POINT, P, ON THE AXIS

$$p^2 = W\left(\frac{\rho c}{4}\right) \left\{\ln\left[1 + (d/R)^{-2}\right]\right\} \qquad (12)$$

By referencing the pressure to .00002 N/m^2 and the power to 10^{-12} watts we obtain

$$\frac{p^2}{p_{ref}^{\,2}} = \frac{W}{W_{ref}} \left(\frac{\rho c}{4}\right) \left[\frac{10^{-12}}{(.00002)^2}\right] \left\{\ln\left[1 + (d/R)^{-2}\right]\right\} \qquad (13)$$

Where: ρc = 408 $kg/m^2/sec$ for air

Taking 10 $\log_{10}$ of each side we obtain

$$10 \log_{10}\left(\frac{p^2}{p^2_{\;ref}}\right) = 10 \log_{10}\left(\frac{W}{W_{ref}}\right) + 10 \log_{10}(.255) + 10 \log_{10}\left\{\ln\left[1 + (d/R)^{-2}\right]\right\} \qquad (14)$$

Equation (14) can be expressed as

$$SPL = PWL_A - 6 + 10 \log_{10} \left\{\ln\left[1 + (d/R)^{-2}\right]\right\} \qquad (15)$$

Where: PWL_A is the power level per unit area

Figure 15 is a plot of the third expression in equation (15) as a function of d/R. The plot shows that in a free-field environment, the noise level should drop off at 6dB per doubling of distance for all points along the axis greater than approximately one diameter (2R) away.

Equation (15) was developed by assuming that source elements on the surface of the propeller radiate omnidirectionally. A similar equation can be developed by considering that each surface element on the plane noise source has some directivity of its own. A directional radiation power can be given by the expression:

$$J_\theta = J_o \cos^n \theta \qquad (16)$$

Where: J_o is the radiation power to the normal of a surface element given in the units watt/m^2/sterad.

θ is the angle between J_θ and the normal to the surface.

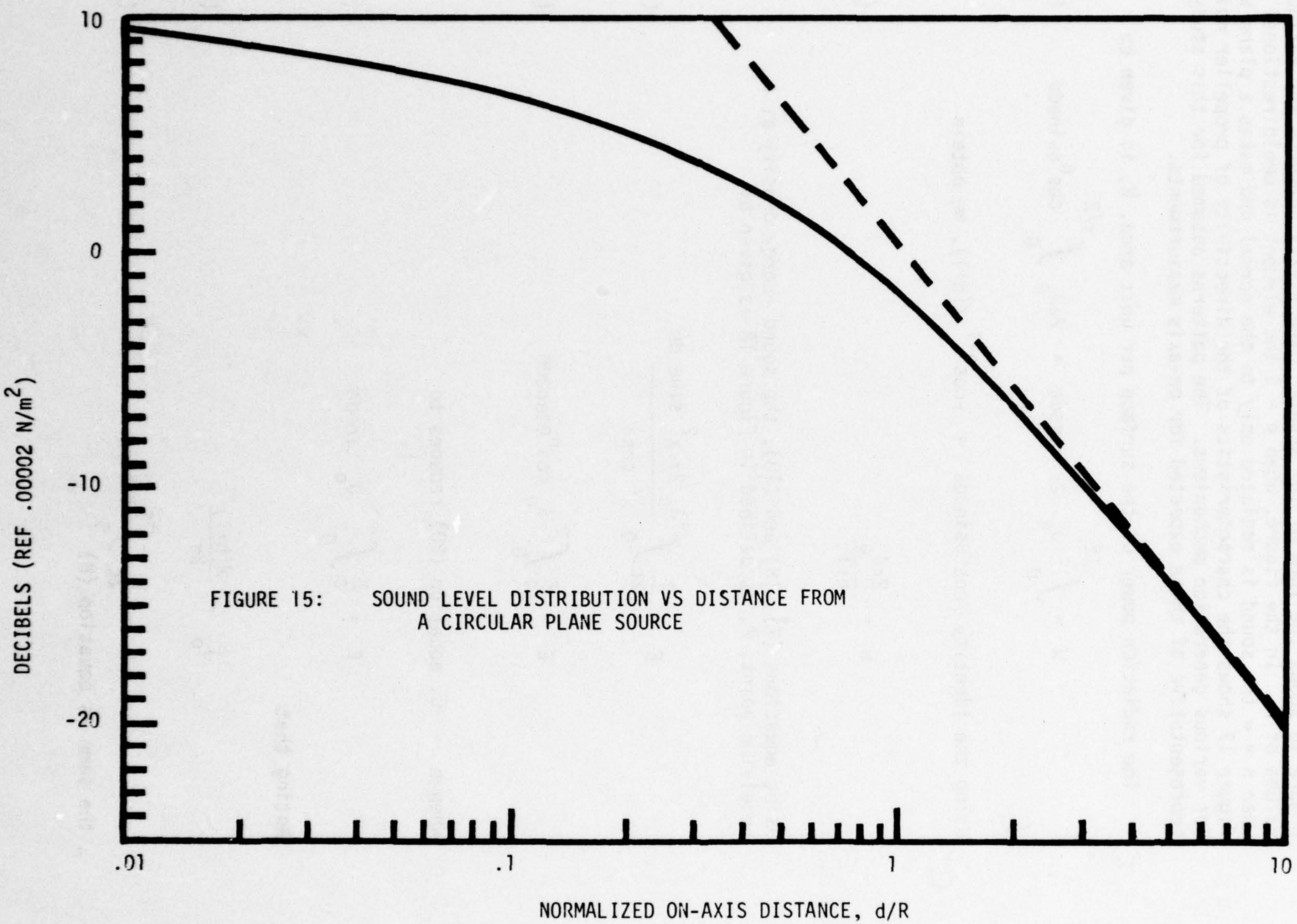


FIGURE 15: SOUND LEVEL DISTRIBUTION VS DISTANCE FROM A CIRCULAR PLANE SOURCE

Figure 16 shows the form of the assumed directivity patterns for various values of n. In the figure, when n = 0 the element is omnidirectional and when n = ∝ the sound is radiated only to the normal and makes a plane wave. Figure 17 shows the characteristics of the directivity of propeller noise for various generation mechanisms. The patterns assumed for this study are representative of those expected for on-axis measurements.

The radiation power of the surface per unit area, W, is given by

$$W = \int_0^{\pi/2} J_\theta \; 2\pi \sin\theta d\theta = 2\pi J_o \int_0^{\pi/2} \cos^n\theta \sin\theta d\theta \qquad (17)$$

Using the identity $\int \cos^n\theta \sin\theta d\theta = -\cos^{n+1} / (n+1)$, we obtain

$$W = \frac{2\pi J_o}{n+1} \qquad (18)$$

Using equations (7), (8) and (18), the sound energy density at a receiving point, P, as defined in Figure 18 is given by

$$E = \frac{1}{2c} \int_0^{\propto} \frac{J_\theta \; 2\pi \; x^2 \sin\theta \; d\theta}{x^2 \cos\theta} \qquad (19)$$

$$E = \frac{\pi}{c} \int_0^{\propto} J_o \cos^n\theta \tan\theta d\theta \qquad (20)$$

When n = 0, equation (20) reduces to

$$E = \frac{\pi}{c} \int_0^{\propto} J_o \tan\theta d\theta \qquad (21)$$

Noting that

$$J_o = \frac{W(n+1)}{2\pi} \qquad (22)$$

$$E = \frac{W}{2c} \int_0^{\propto} \tan\theta d\theta \qquad (23)$$

the same as equation (8)

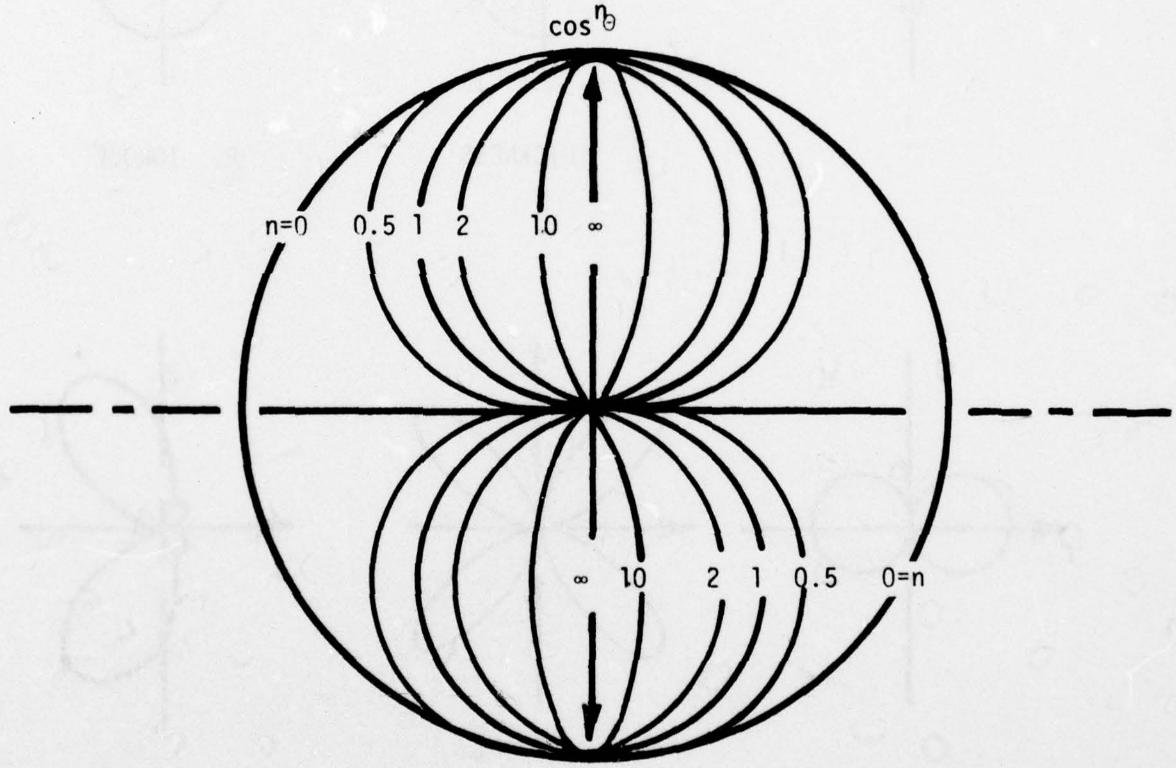


FIGURE 16: ASSUMED DIRECTIVITY PATTERN FOR SOUND RADIATION FROM ELEMENTAL SOURCES DISTRIBUTED

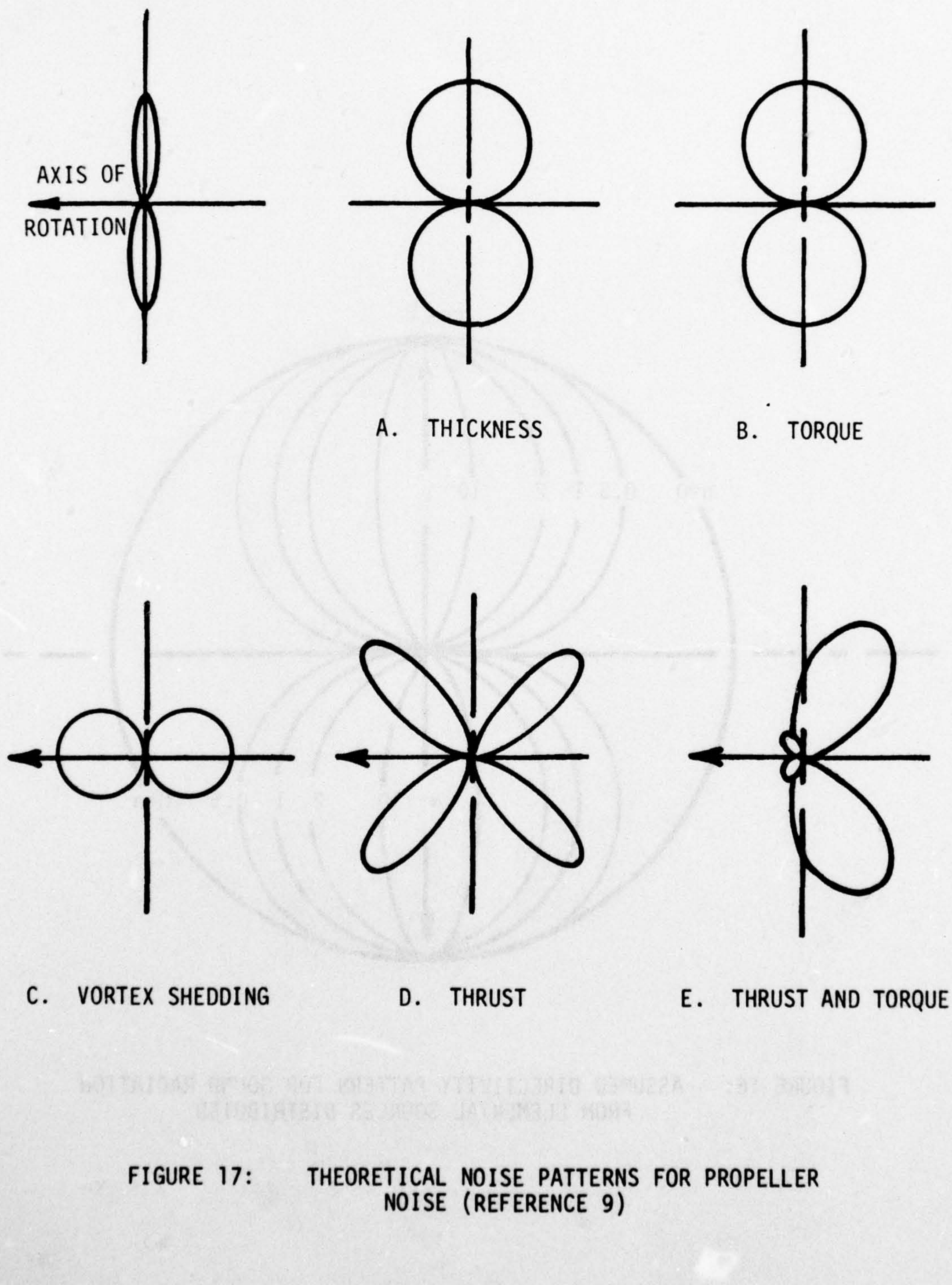


FIGURE 17: THEORETICAL NOISE PATTERNS FOR PROPELLER NOISE (REFERENCE 9)

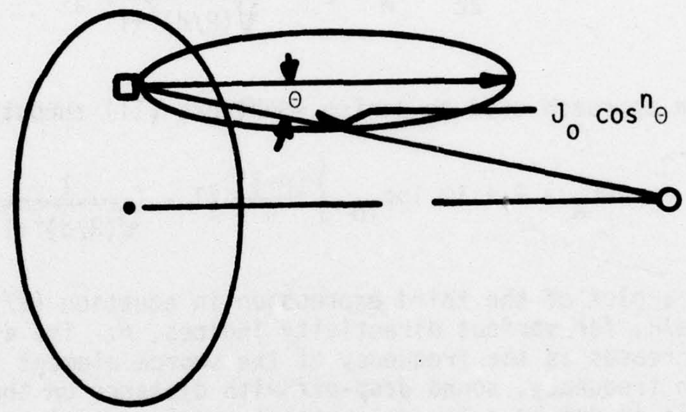


FIGURE 18: GEOMETRY FOR AN ASSUMED ELEMENTAL SOURCE DIRECTIVITY PATTERN AS VIEWED FROM A MEASUREMENT POINT, P, ON THE AXIS.

When n > 0, equation (20) becomes

$$E = \frac{W(n+1)}{2c} \int_0^{\alpha} \cos^n\Theta \tan\Theta \, d\Theta \tag{24}$$

Using the identity $\int \cos^n\Theta \tan\Theta \, d\Theta = -\cos^n\Theta/n$, we obtain

$$E = \frac{W}{2c} \frac{(n+1)}{n} [1 - (\cos\alpha)^n] \tag{25}$$

Replacing $\cos\alpha$ with the proper rectilinear coordinates yields

$$E = \frac{W}{2c} \frac{(n+1)}{n} \left[1 - \left(\frac{1}{\sqrt{(R/d)^2+1}}\right)^n\right] \tag{26}$$

Repeating the approach used to derive equations (11) through (15), we obtain

$$SPL = PWL_A - 3 + 10 \log_{10} \left\{ \frac{(n+1)}{n} \left[1 - \left(\frac{1}{\sqrt{(R/d)^2+1}}\right)^n\right] \right\} \tag{27}$$

Figure 19 is a plot of the third expression in equation (27) as a function of d/R, for various directivity indices, n. The directivity index, n, increases as the frequency of the source element increases. Therefore, at high frequency, sound drop-off with distance on the center axis is gradual. This is not true for measurement points out of the center axis.

In order to compare equations (15) and (27) with equation (6), the equations must be converted to total power level equations where the total power level, PWL, is given by

$$PWL = PWL_A + 10 \log_{10} \pi R^2 \tag{28}$$

Therefore, equations (15) and (27) can be expressed as follows:

For n = 0

$$SPL\text{-}PWL = -6 - 10 \log_{10} \pi R^2 + 10 \log_{10} \left\{ \ln[1+(d/R)^{-2}] \right\} \tag{29}$$

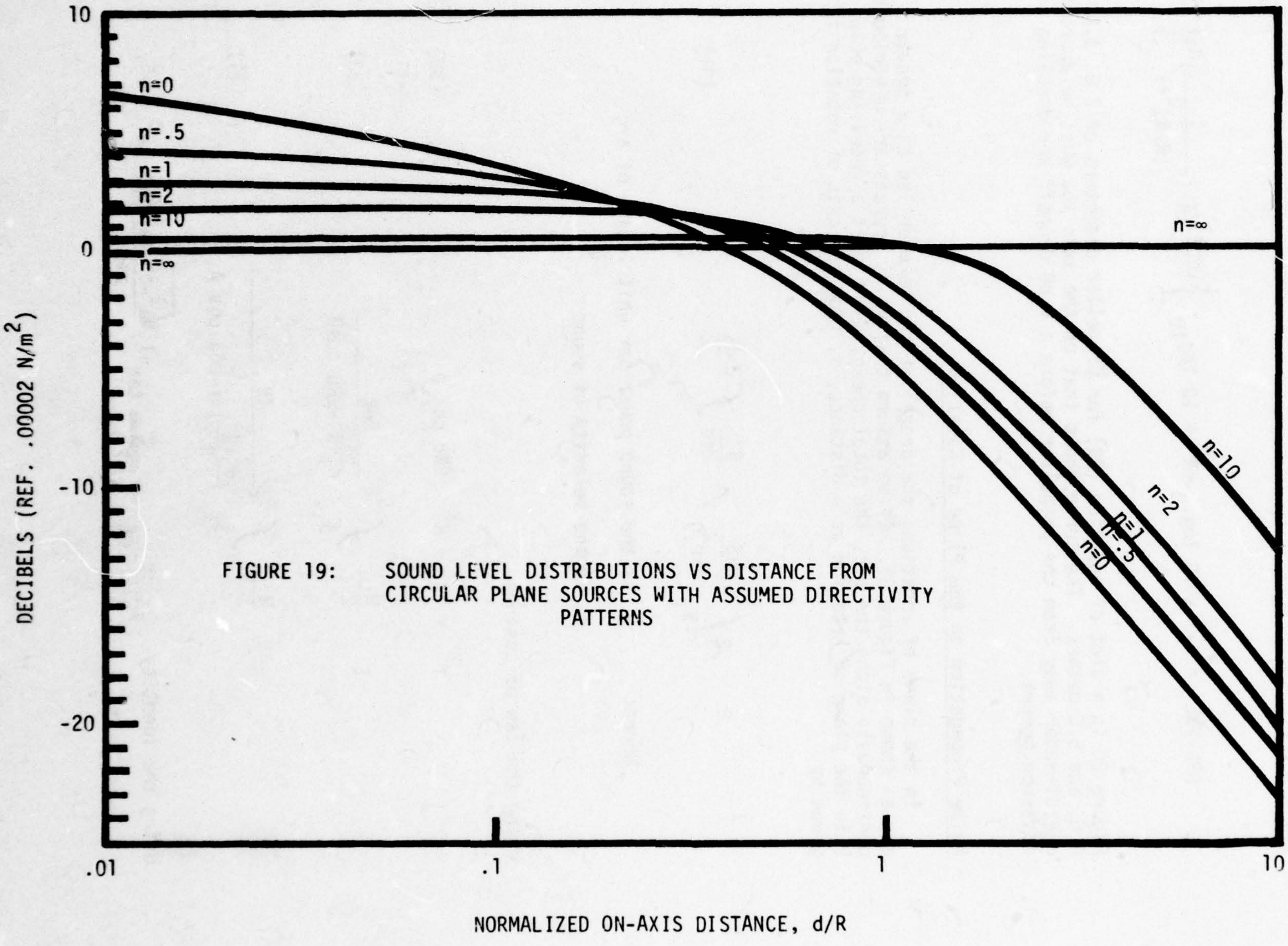


FIGURE 19: SOUND LEVEL DISTRIBUTIONS VS DISTANCE FROM CIRCULAR PLANE SOURCES WITH ASSUMED DIRECTIVITY PATTERNS

For n > 0

$$\text{SPL-PWL} = -3 - 10 \log_{10} \pi R^2 + 10 \log_{10} \left\{ \frac{(n+1)}{n} [1 - (\frac{1}{(R/d)^2+1})^n] \right\} \quad (30)$$

Figure 20 is a plot of equation (29) for propeller diameters of 2.0, 3.0, 4.0, and 5.0 meters. The curve shows that on the axis you must be approximately one diameter away from the propeller before a 6 dB dropoff per doubling of distance occurs.

Noise Propagation in the Plane of Rotation

In the plane of rotation, the propeller can be modelled as a convex arc as shown in Figure 21. If we assume that point sources are distributed continuously along the arc, the total energy density at a receiving point P in the plane of rotation at a distance, d, from the axis of rotation is given by

$$E = 2\int_{S_1}^{S_2} \frac{WdS}{4\pi r^2 c} = \frac{W}{2\pi c} \int_{S_1}^{S_2} \frac{dS}{r^2} \quad (31)$$

Where: W is the sound power per unit length of arc

c is the velocity of sound

Using the law of cosines

$$r^2 = d^2 + R^2 - 2Rd \cos \emptyset \quad (32)$$

$$E = \frac{W}{2\pi c} \int_{S_1}^{S_2} \frac{Rd\emptyset}{d^2+R^2-2Rd \cos\emptyset} \quad (33)$$

$$E = \frac{W}{2\pi c} \int_{S_1}^{S_2} \frac{d\emptyset}{(\frac{d^2+R^2}{R})+(-2d) \cos \emptyset} \quad (34)$$

Using the identity $\int \frac{d\emptyset}{a+b\cos\emptyset} = \frac{2}{\sqrt{a^2-b^2}} \tan^{-1} \frac{\sqrt{a^2-b^2} \tan \emptyset/2}{a+b} \quad a^2 > b^2,$

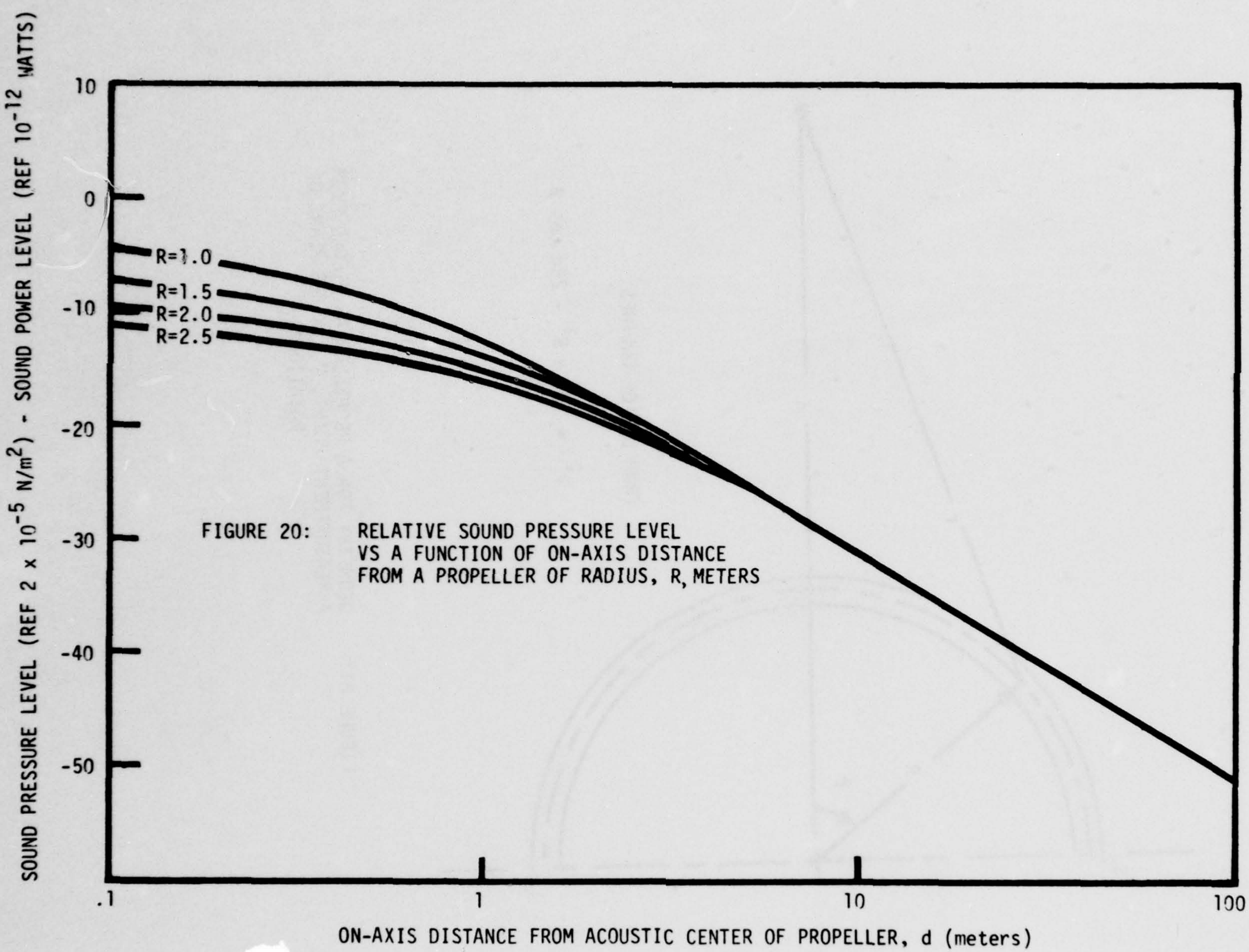
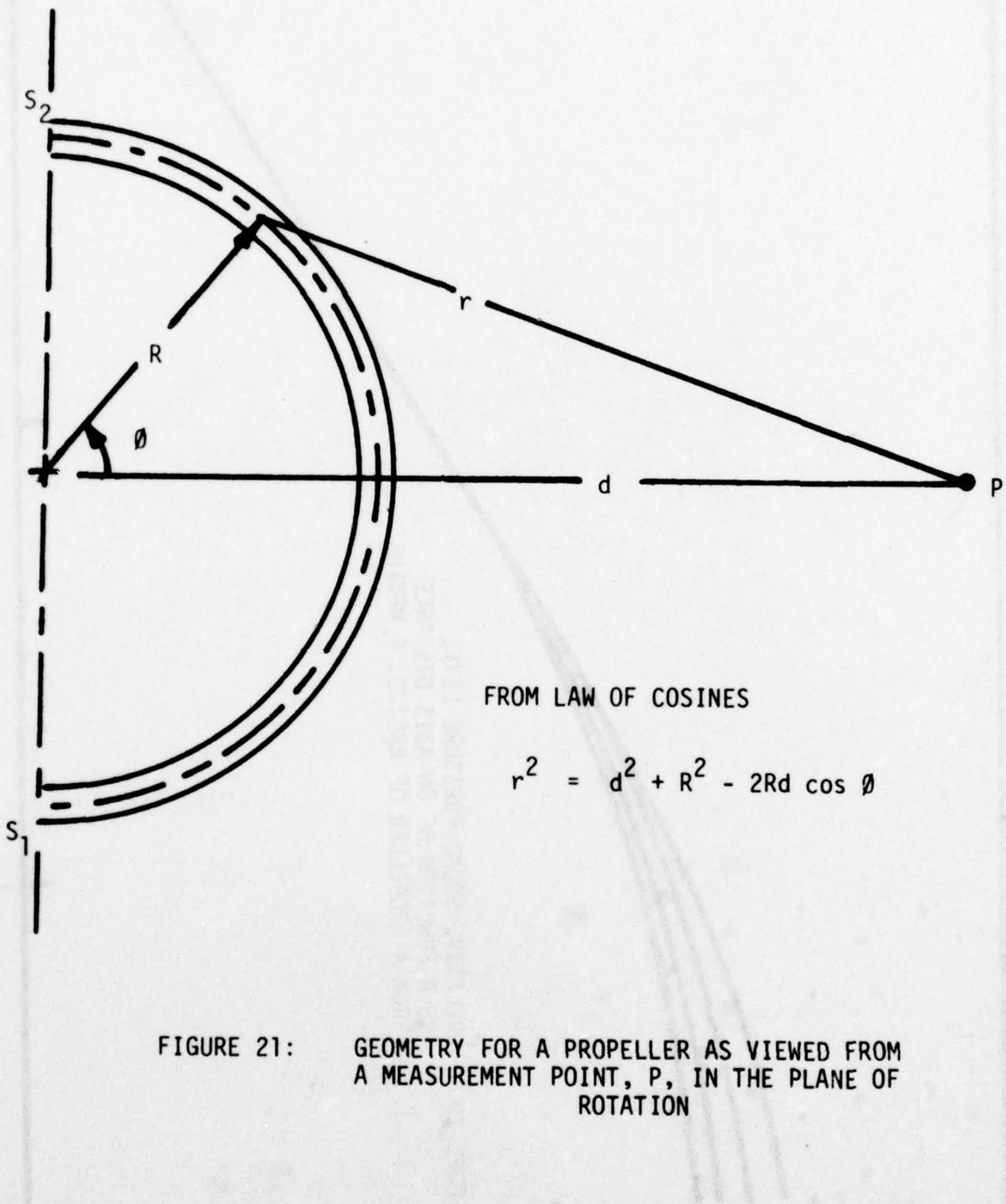


FIGURE 20: RELATIVE SOUND PRESSURE LEVEL VS A FUNCTION OF ON-AXIS DISTANCE FROM A PROPELLER OF RADIUS, R, METERS



FROM LAW OF COSINES

$$r^2 = d^2 + R^2 - 2Rd \cos \emptyset$$

FIGURE 21: GEOMETRY FOR A PROPELLER AS VIEWED FROM A MEASUREMENT POINT, P, IN THE PLANE OF ROTATION

we obtain

$$E = \frac{W}{\pi c}\left[\frac{1}{\sqrt{a^2-b^2}}\tan^{-1}\left(\frac{\sqrt{a^2-b^2}}{a+b}\tan \phi/2\right)\right]_{\phi = -\pi/2}^{\phi = \pi/2} \qquad (35)$$

$$E = \frac{W}{\pi c}\left[\frac{1}{\sqrt{a^2-b^2}}\tan^{-1}\left(\frac{\sqrt{a^2-b^2}}{a+b}(+1)\right) - \frac{1}{\sqrt{a^2-b^2}}\tan^{-1}\left(\frac{\sqrt{a^2-b^2}}{a+b}(-1)\right)\right] \qquad (36)$$

$$E = \frac{2W}{\pi c}\left[\frac{1}{\sqrt{a^2-b^2}}\tan^{-1}\left(\frac{\sqrt{a^2-b^2}}{a+b}\right)\right] \qquad (37)$$

$$E = \frac{2W}{\pi c}\left[\frac{1}{\sqrt{\left(\frac{d^2+R^2}{R}\right)^2-4d^2}}\tan^{-1}\left(\frac{\sqrt{\left(\frac{d^2+R^2}{R}\right)^2-4d^2}}{\frac{d^2+R^2}{R}-2d}\right)\right] \qquad (38)$$

$$E = \frac{2W}{\pi c}\left[\frac{1}{\sqrt{\frac{(d^2+R^2)^2-4d^2R^2}{R^2}}}\tan^{-1}\left(\frac{\sqrt{\frac{(d^2+R^2)^2-4d^2R^2}{R^2}}}{\frac{(d^2+R^2)-2dR}{R}}\right)\right] \qquad (39)$$

$$E = \frac{2W}{\pi c}\left[\frac{R}{d^2-R^2}\tan^{-1}\left(\frac{d+R}{d-R}\right)\right] \qquad (40)$$

$$E = \frac{2W}{\pi cR}\left[\frac{1}{(d/R)^2-1}\tan^{-1}\left(\frac{d/R+1}{d/R-1}\right)\right] \qquad (41)$$

Repeating the approach used to derive equations (11) through (15), we obtain

$$SPL = PWL_L + 3 - 10\log_{10}\pi R + 10\log_{10}\left[\frac{1}{(d/R)^2-1}\tan^{-1}\left(\frac{d/R+1}{d/R-1}\right)\right] \qquad (42)$$

Where: PWL_L is the power level per unit length

If we assume that the length of radiating arc is equal to the propeller circumference, we obtain the following expression for total power level

$$PWL = PWL_L + 10 \log_{10} 2\pi R \tag{43}$$

Therefore,

$$SPL\text{-}PWL = -20 \log_{10} \pi R + 10 \log_{10} \left[\frac{1}{(d/R)^2-1} \tan^{-1} \left(\frac{d/R+1}{d/R-1}\right)\right] \tag{44}$$

Figure 22 is a plot of the third expression of equation (44) as a function of d/R. The curve shows that the plane of rotation measurement points must be approximately 3 diameters from the propeller blade tip before a true 6 dB per doulbing of distance is obtained. Figure 23 is a plot of equation (44) as a function of measurement distance, d, and propeller radius, R, in meters. This result can be directly compared with the result from equation (6) as plotted in Figure 11 to determine the effects of reverberation and source geometry on the noise propagation characteristics.

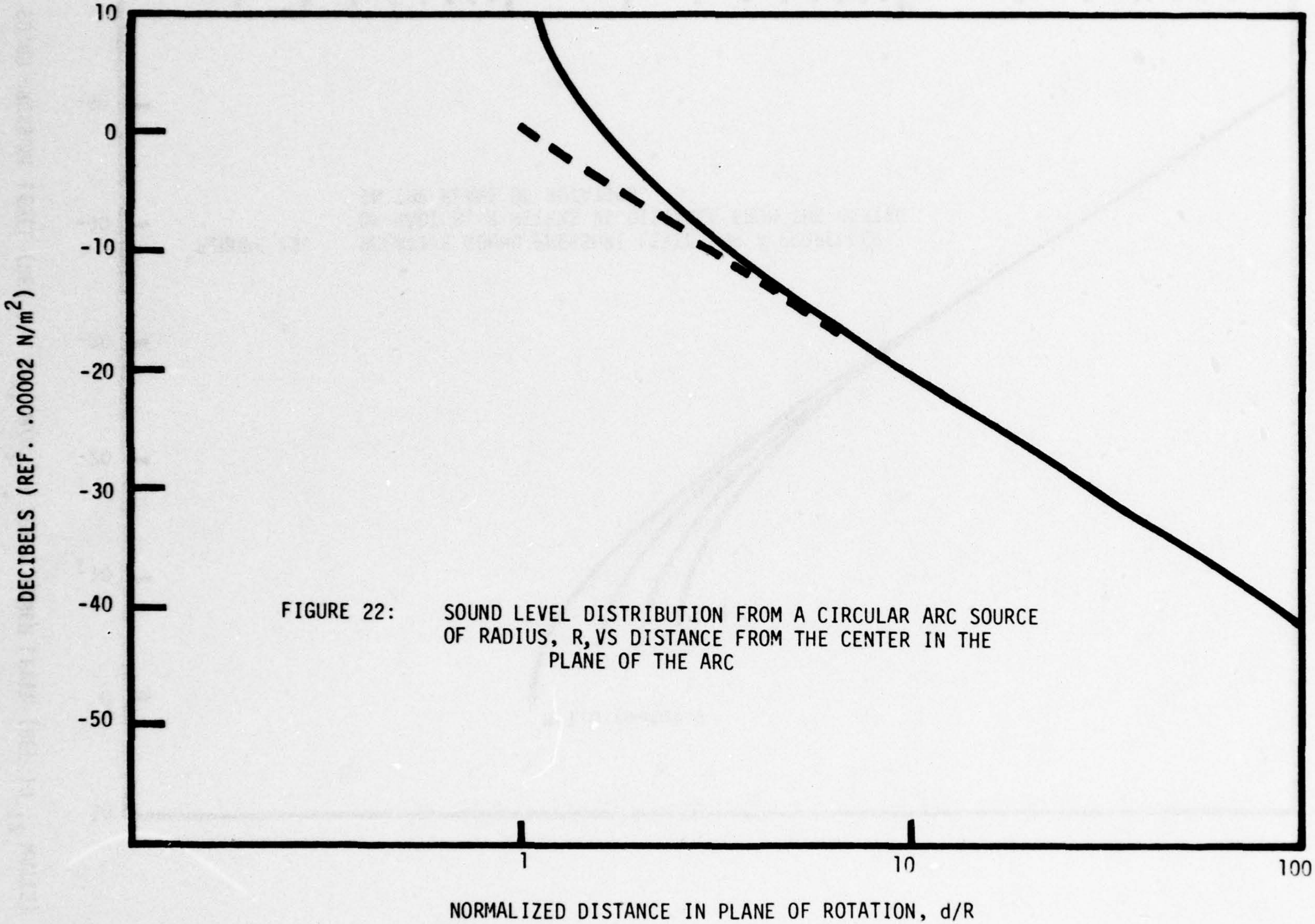


FIGURE 22: SOUND LEVEL DISTRIBUTION FROM A CIRCULAR ARC SOURCE OF RADIUS, R, VS DISTANCE FROM THE CENTER IN THE PLANE OF THE ARC

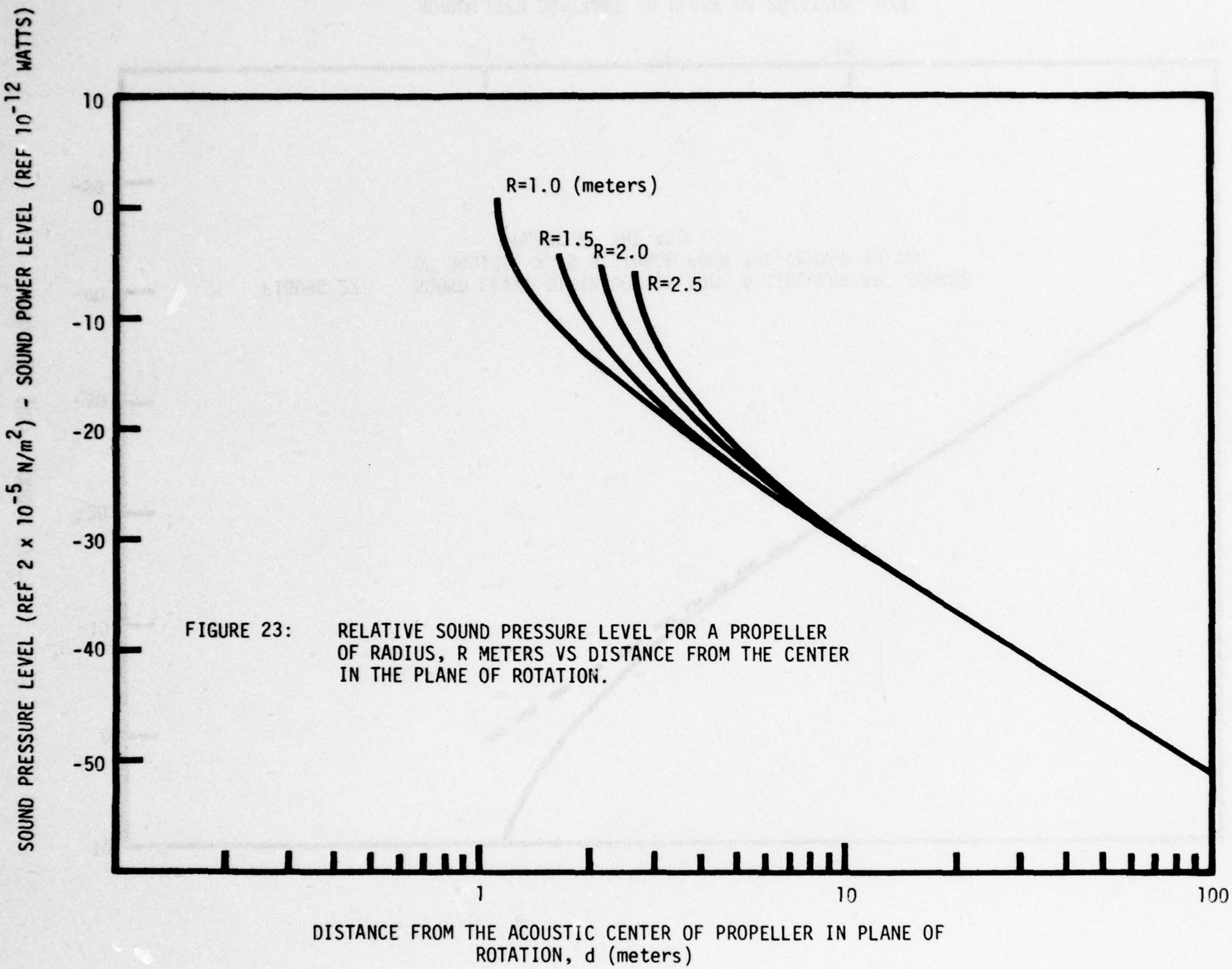


FIGURE 23: RELATIVE SOUND PRESSURE LEVEL FOR A PROPELLER OF RADIUS, R METERS VS DISTANCE FROM THE CENTER IN THE PLANE OF ROTATION.

VII. CONCLUSIONS AND RECOMMENDATIONS

This report has described the development of an indoor acoustic test facility for static testing of fans and propellers. The performance measurement system has been used for many years with demonstrated accuracy and dependability. The acoustic characteristics of the facility have been thoroughly studied and documented. The problem of data contamination due to acoustic reflections has been minimized by the use of high absorption acoustic treatment on the near walls and the floor of the test rig. Room mode interactions are not considered significant above 60 Hertz due to the large size of the room. Reverberation characteristics for the facility have been thoroughly evaluated and can be used to correct measured data where necessary. Finally, background noise has been assessed and is not considered a problem for most propeller and fan configurations. However, background noise measurements are made an integral part of each test program to ensure that the test data is not contaminated in the frequency range of interest.

In Section six of this report, a brief study was made to assess acoustic propagation characteristics with distance in the plane of rotation and along the propeller axis. Characteristic curves for on-axis propagation (Figure 20) and plane of rotation propagation (Figure 22) should be developed for the propeller under test. These curves, together with the facility reverberation curves can then be used to select optimum microphone measurement arrays. For propellers in the diameter range of 2 to 4 meters, the optimum location for far-field measurements in this facility falls between one and two diameters from the propeller center in the plane of rotation. The farthest microphone point is limited by wall effects and reverberation while the nearest microphone position is limited by the extent of the propeller near field. The propeller near field is generally defined as the space within one propeller diameter from the blade tips. Measurements in this area are generally free from interference by reflection, reverberation, and background noise, but do not show the directivity patterns characteristic of far-field noise. Near-field noise does not exhibit radial variation in sound pressure in accordance with the far-field "inverse square law" where the level drops 6 dB per doubling of distance (Reference 9).

A number of useful data presentation programs have been developed to aid in assessing noise/performance tradeoffs for the articles under test. These programs were described in Section V and detailed listings with sample plots are shown in Appendix B. This plotting capability coupled with the performance and acoustic measurement systems provides a very versatile tool for conducting static propeller/fan performance and acoustic tests and for conducting noise/performance trade studies.

VIII. REFERENCES

1. McErlean, D. P., and Edwards, D. E., "Performance and Acoustic Testing of a Variable Camber Propeller," AFAPL Technical Report 70-80, Air Force Aero-Propulsion Laboratory, Wright-Patterson AFB, Ohio, February 1971.

2. Cafarelli, G. T., and Chopin, M. H., "Computer Program for Reducing Static Propeller Test Data," ASD Technical Report 68-19, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, June 1968.

3. Chopin, M. H., "Propeller Static Performance Tests for V/STOL Aircraft, Part I - Summary Report," ASD Technical Report 69-15, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, January 1970.

4. Berger, R., and Winemiller, G., "XYZPLT - A Computer Plotting Routine for Engineering Applications," ASD Technical Report 73-50, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, February 1974.

5. Anon., "Investigation of the Feasibility of Making Model Acoustic Measurements in the NASA Ames 40 x 80 Ft. Wind Tunnel," Contract NAS2-5742, Bolt, Beranek and Newman Report 1870, 15 April1970.

6. Beranek, L. L., Noise Reduction, McGraw-Hill Book Company, 1960.

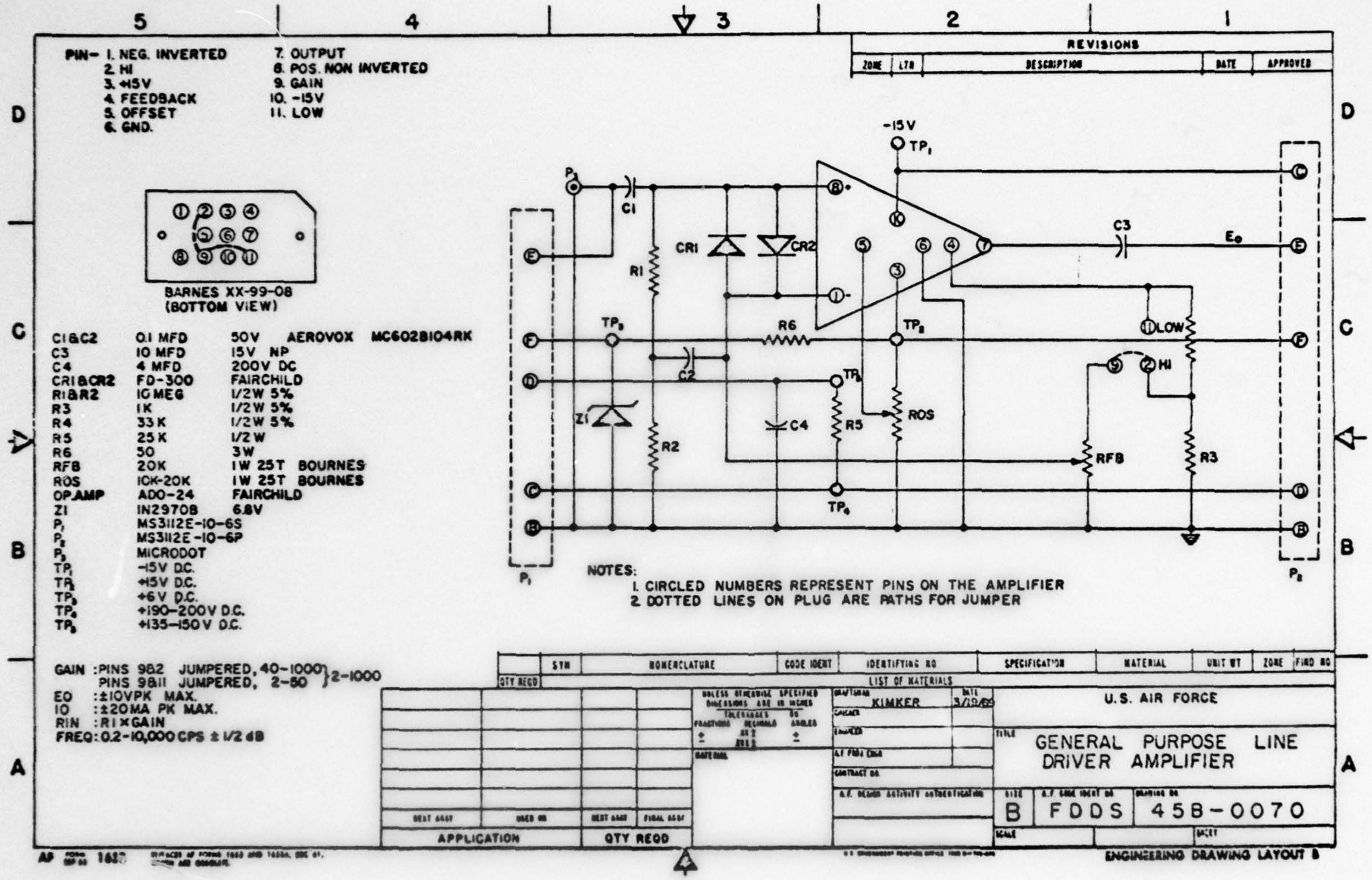
7. Brown, D., and Ollerhead, "Propeller Noise at Low Tip Speeds," AFAPL-TR-71-55, Wright-Patterson AFB, Ohio, September 1971.

8. Maekawa, Z., "Noise Reduction by Distance from Sources of Various Shapes," Applied Acoustics (3)(1970), Elsevier Publishing Company Ltd, England.

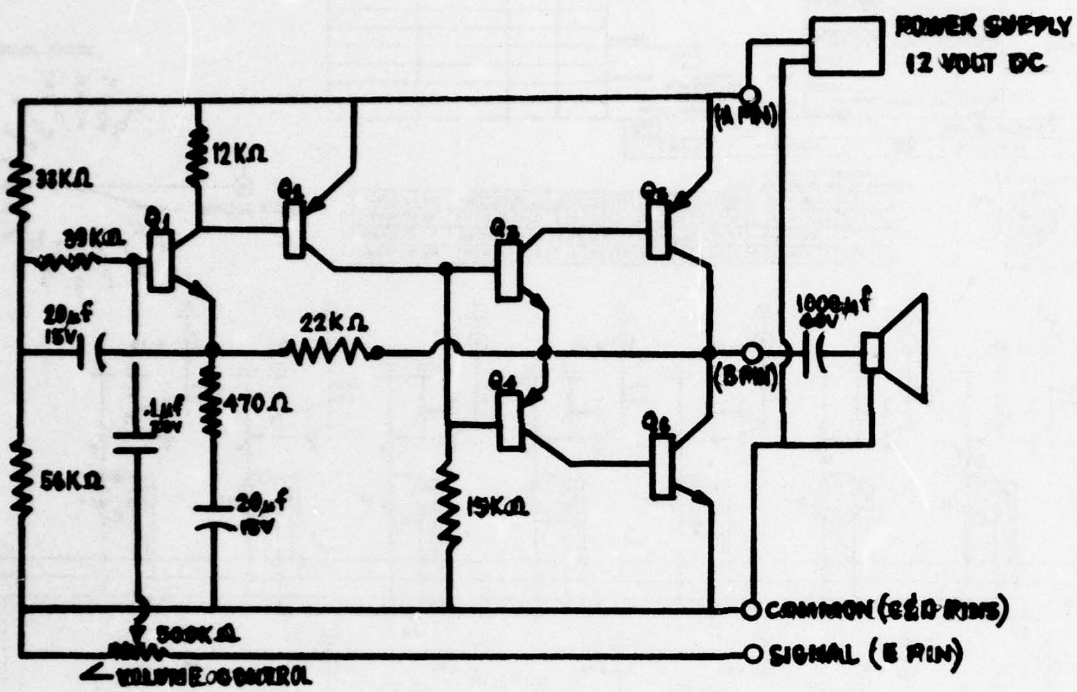
9. Anon., "A Study of Propeller Noise Research," Hamilton Standard Division of United Aircraft Corporation, SP 67148, Revision A, November 1967.

APPENDIX A

DETAILED SCHEMATICS - ACOUSTIC DATA SYSTEM


PIN- 1. NEG. INVERTED
2. HI
3. +15V
4. FEEDBACK
5. OFFSET
6. GND.
7. OUTPUT
8. POS. NON INVERTED
9. GAIN
10. -15V
11. LOW
BARNES XX-99-08
(BOTTOM VIEW)
C1&C2 0.1 MFD 50V AEROVOX MC6028104RK
C3 10 MFD 15V NP
C4 4 MFD 200V DC
CR1&CR2 FD-300 FAIRCHILD
R1&R2 10 MEG 1/2W 5%
R3 1K 1/2W 5%
R4 33K 1/2W 5%
R5 25K 1/2W
R6 50 3W
RFB 20K 1W 25T BOURNES
ROS 10K-20K 1W 25T BOURNES
OP.AMP ADO-24 FAIRCHILD
Z1 1N2970B 6.8V
P1 MS3112E-10-6S
P2 MS3112E-10-6P
P3 MICRODOT
TP1 -15V DC.
TP2 +15V D.C.
TP3 +6V D.C.
TP4 +190-200V D.C.
TP5 +135-150V D.C.
GAIN :PINS 9&2 JUMPERED, 40-1000 } 2-1000
PINS 9&11 JUMPERED, 2-50
EO :±10VPK MAX.
IO :±20MA PK MAX.
RIN :R1×GAIN
FREQ: 0.2-10,000 CPS ± 1/2 dB
-15V
TP1
C1
C2
C3
C4
CR1
CR2
R1
R2
R3
R5
R6
RFB
ROS
Z1
LOW
HI
Eo
P1
P2
NOTES:
1. CIRCLED NUMBERS REPRESENT PINS ON THE AMPLIFIER
2. DOTTED LINES ON PLUG ARE PATHS FOR JUMPER
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
QTY REQD SYM NOMENCLATURE CODE IDENT IDENTIFYING NO SPECIFICATION MATERIAL UNIT WT ZONE FIND NO
LIST OF MATERIALS
APPLICATION
QTY REQD
KIMKER 3/12/69
U.S. AIR FORCE
GENERAL PURPOSE LINE DRIVER AMPLIFIER
B FDDS 45B-0070
ENGINEERING DRAWING LAYOUT B

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL



Q_1 = 2N3794	
Q_2 = 2N3702	
Q_3 = 2N1302	
Q_4 = 2N1305	
Q_5 = 2N5322	
Q_6 = 2N5320	
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
FRACTIONS ± DECIMALS .XX± .XXX± ANGLES ±

3.7 WATTS RMS CONTINUOUS
INPUT Z = 500K Ω
OUTPUT Z = 8 Ω
VOLTAGE GAIN ≅ 50

DRAFTSMAN	R. Shelaly	DATE 26 OCT 76
CHECKER	R. Felger	26 OCT 76
ENGINEER	R. Shelaly	26 OCT 76
A.F. PROJ. ENGR.		
CONTRACT NO.	30661208	
A.F. DESIGN ACTIVITY AUTHENTICATION		

U.S. AIR FORCE

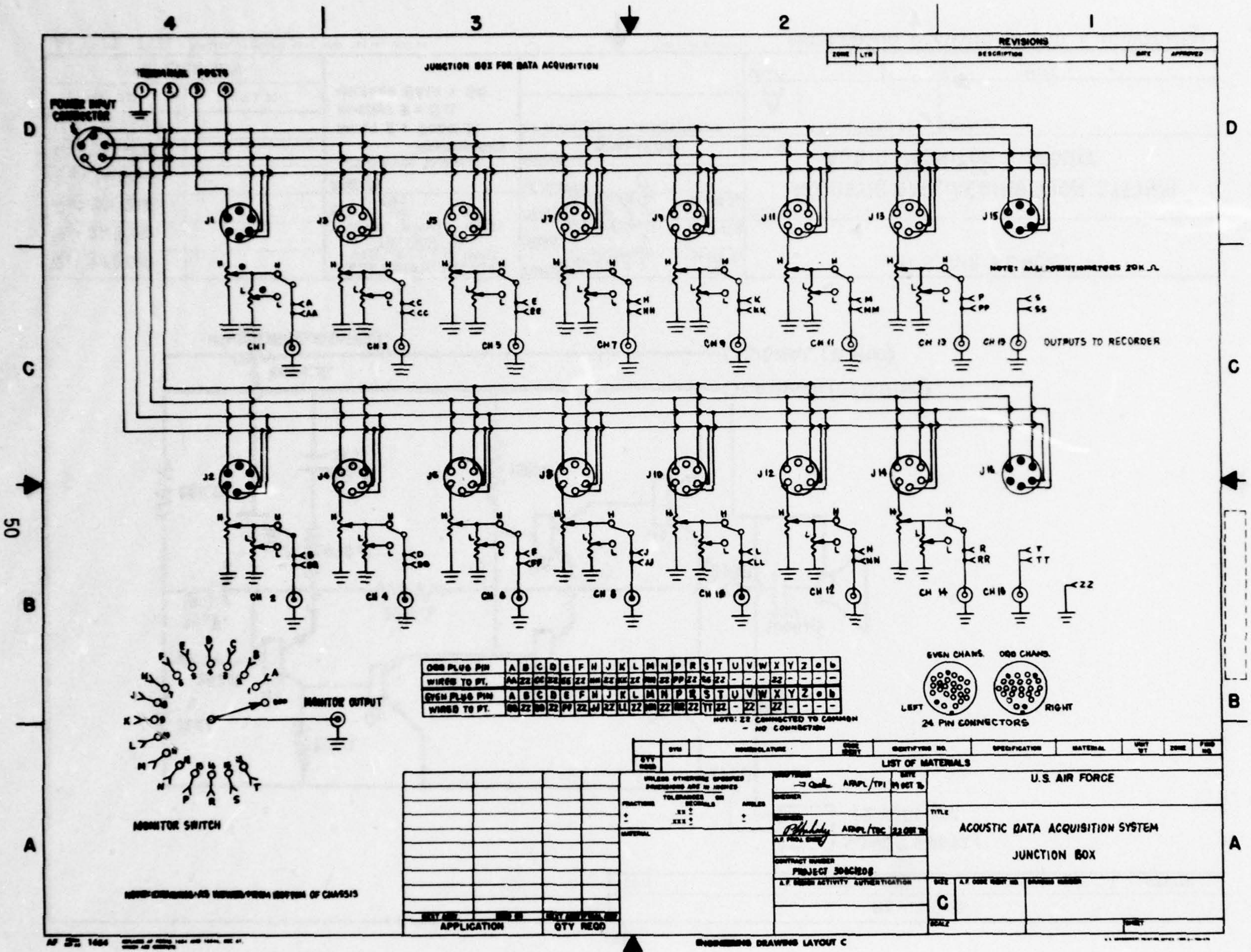
TITLE
ACOUSTIC DATA ACQUISITION SYSTEM
AUDIO MONITOR CIRCUIT

SIZE	A.F. CODE IDENT NO.	DRAWING NO.
A		
SCALE		SHEET

AF FORM SEP 65 1651 REPLACES AF FORMS 1651 AND 1651A, DEC 61, WHICH ARE OBSOLETE.

GPO : 1965 O—790-482

ENGINEERING DRAWING LAYOUT A HORIZONTAL



ODD PLUG PIN	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z	a	b
WIRED TO PT.	AA	ZZ	CC	ZZ	EE	ZZ	HH	ZZ	KK	ZZ	MM	ZZ	PP	ZZ	SS	ZZ	-	-	-	ZZ	-	-	-	-
EVEN PLUG PIN	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z	a	b
WIRED TO PT.	BB	ZZ	DD	ZZ	FF	ZZ	JJ	ZZ	LL	ZZ	NN	ZZ	RR	ZZ	TT	ZZ	-	ZZ	-	ZZ	-	-	-	-

APPENDIX B

DATA PRESENTATION PROGRAMS

APPENDIX B-1

PROGRAM HORSE

```
RM5,STCSA,CM77777,T20,I020. P720119 MCGREGOR 52744
FTN,R=3.
MAP,PART.
ATTACH,CCAUX,CCAUX,ID=X654321.
LIBRARY,CCAUX.
LGO.
"   END OF RECORD
      PROGRAM HORSE (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PLOT)
C *** PROGRAM HORSE IS USED TO PLOT THRUST VS HORSEPOWER FOR VARIOUS
C     QUIET PROPELLER CONFIGURATIONS.  IT WILL ACCEPT DATA WITH 3 OR 5
C     RPM RUNS.
C
C    PRESET PARAMETERS (NAMELIST):
C        IORPM = (1) .. ALL AVAILABLE DATA USED IN PLOTS
C                 2  .. 3 RPM VALUES USED REGARDLESS OF DATA INPUT
C        MINIMUM THRUST (YMIN) = 0.
C        MAXIMUM THRUST (YMAX) = 1600.
C        MINIMUM HORSEPOWER (XMIN) = 0.
C        MAXIMUM HORSEPOWER (XMAX) = 240.
C        RPM DATA POINTS (WRPM(1-5)) = 600.,750.,900.,1050.,1200.
C
C      * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C        NAMELIST FORMAT  (EXAMPLE: $INPUT YMIN=10.,XMIN=100.$)
C
      INTEGER HEAD
      DIMENSION HEAD(40), BETA(3), X(2,3,5), CX(7), CY(7), WRPM(5)
      NAMELIST/INPUT/ WRPM,IORPM,YMIN,YMAX,XMIN,XMAX
      DATA WRPM/600.,750.,900.,1050.,1200./
      IORPM=1 $ YMIN=0. $ YMAX=1600. $ XMIN=0. $ XMAX=240.
      CALL PLOT (0.,1.,-3)
    1 READ(5,INPUT)
      YSTEP=(YMAX-YMIN)/8.0
      XSTEP=(XMAX-XMIN)/6.0
C ** READ IN NUMBER OF RPM RUNS
    2 READ (5,8) NRPM
      IF(NRPM.EQ.99999) GO TO 1
      IF (NRPM.EQ.0) GO TO 7
      CALL READER(HEAD,BETA,X,Y,NRPM,0,IORPM,NSIZ,0)
      CALL CENTER (HEAD,40)
C ** SET UP AXIS FOR PLOTTING
      CALL AXIS (0.,0.,21HTHRUST (POUNDS FORCE),21,8.,90.,YMIN,YSTEP)
      CALL AXIS (0.,0.,10HHORSEPOWER,-10,6.5,0.,XMIN,XSTEP)
      ENCODE(40,100,HEAD) HEAD
  100 FORMAT(40A1)
      CALL SYMBOL (0.25,8.35,0.15,HEAD,0.,40)
C ** SET UP DATA ARRAY FOR CONSTANT BLADE ANGLES
      DO 4 I=1,3
      DO 3 J=1,NSIZ
      CX(J)=X(1,I,J)
    3 CY(J)=X(2,I,J)
      CX(NSIZ+1)=XMIN
      CX(NSIZ+2)=XSTEP
      CY(NSIZ+1)=YMIN
      CY(NSIZ+2)=YSTEP
C ** PLOT POINTS AND DRAW A SMOOTH CURVE
      CALL FLINE (CX,CY,-NSIZ,1,1,(I-1))
```

```
C ** DRAW LEGEND BY END OF LINE
      CALL WLINE (CX,CY,(NSIZ+2),0.,XL,YL)
      CALL SYMBOL ((XL+.1),YL,.08,22H--       DEG. BLADE ANGLE,0.,22)
    4 CALL NUMBER ((XL+.34),YL,0.08,BETA(I),0.,-1)
C ** SET UP DATA ARRAY FOR CONSTANT RPM'S
      DO 6 J=1,NSIZ
      DO 5 I=1,3
      CX(I)=X(1,I,J)
    5 CY(I)=X(2,I,J)
      CX(4)=XMIN
      CX(5)=XSTEP
      CY(4)=YMIN
      CY(5)=YSTEP
C ** PLOT POINTS AND DRAW A SMOOTH CURVE
      CALL FLINE (CX,CY,-3,1,1,(J-1))
C ** DRAW LEGEND BY END OF LINE
      CALL WLINE (CX,CY,5,90.,XL,YL)
      CALL SYMBOL (XL,(YL+.1),.08,11H--        RPM,90.,11)
C ** COMPUTE DESIRED INDEX FOR TITLE'S RPM VALUE
      LABEL=IFIX(FLOAT(J)*(5.0/FLOAT(NSIZ))+.001)
    6 CALL NUMBER (XL,(YL+.34),.08,WRPM(LABEL),90.,-1)
      CALL PLOT (9.5,0.,-3)
      GO TO 2
    7 CONTINUE
      CALL PLOTE
      STOP
C
    8 FORMAT (10I5)
      END
```

BEST AVAILABLE COPY

```
      SUBROUTINE READER (HEAD,BETA,X,Y,NRPM,NMIKE,IORPM,NSIZ,IOJBA)
      DIMENSION HEAD(40), X(2,3,5), Y(4,3,5), BETA(3)
      INTEGER HEAD
      READ (5,14) HEAD
      IF (IORPM.EQ.1) GO TO 9
      IF (IORPM.EQ.2.AND.NRPM.EQ.3) GO TO 9
C ** READ 3 POINTS IF 5 ARE AVAILABLE
      DO 2 I=1,3
      READ (5,15) BETA(I)
      DO 1 J=1,2
      READ (5,16) RPM,X(1,I,J),X(2,I,J)
    1 READ (5,17) TRASH
    2 READ (5,16) RPM,X(1,I,3),X(2,I,3)
    8 NSIZ=3
      GO TO 13
C ** READ ALL AVAILABLE DATA
    9 DO 10 I=1,3
      READ (5,15) BETA(I)
      DO 10 J=1,NRPM
   10 READ (5,16) RPM,X(1,I,J),X(2,I,J)
      NSIZ=NRPM
   13 RETURN
C
   14 FORMAT (40A1)
   15 FORMAT (30X,F10.3)
   16 FORMAT (3F10.3)
   17 FORMAT (F10.3)
      END


      SUBROUTINE CENTER (HEAD,LENGTH)
C *** SUBROUTINE CENTER IS USED TO CENTER A HEADING WITHIN A VARIABLE-
C     LENGTH TITLE LINE
      INTEGER HEAD
      DIMENSION HEAD(LENGTH)
      INK=0
C ** COUNT THE RIGHT-HAND BLANKS
    1 LOC=LENGTH-INK
      IF (HEAD(LOC).NE.1H ) GO TO 2
      INK=INK+1
      GO TO 1
C ** PLACE HALF THE DETECTED BLANKS ON THE HEADING'S LEFT SIDE
    2 MOVE=IFIX(((FLOAT(INK))/2)+.001)
      IF(MOVE.EQ.0) RETURN
      DO 4 I=1,MOVE
      N=LENGTH-1
      IPOS=LENGTH+1
      DO 3 J=1,N
    3 HEAD(IPOS-J)=HEAD(LENGTH-J)
    4 HEAD(I)=1H
      RETURN
      END
```

```
      SUBROUTINE WLINE (X,Y,N,WCH,XL,YL)
C *** SUBROUTINE WLINE ARRANGES DATA SETS IN DECREASING ORDER RESPECTIVE
C     TO EITHER X OR Y.  IT THEN RETURNS THE PHYSICAL PAGE COORDINATES
C     OF THE DATA SET FOUND GREATEST RELATIVE TO THE OTHERS.
      DIMENSION X(N), Y(N)
      IP2=N-3
      IP3=N-2
      DO 3 I=1,IP2
      IP1=I+1
      DO 3 J=IP1,IP3
      IF (WCH.EQ.90.) GO TO 1
C ** COMPARE "X" VALUES
      IF (X(I).GE.X(J)) GO TO 3
      GO TO 2
C ** COMPARE "Y" VALUES
    1 IF (Y(I).GE.Y(J)) GO TO 3
C ** INTERCHANGE THE OUT-OF-ORDER X-Y DATA SETS
    2 TEMP=X(I)
      X(I)=X(J)
      X(J)=TEMP
      TEMP=Y(I)
      Y(I)=Y(J)
      Y(J)=TEMP
    3 CONTINUE
C ** COMPUTE THE PHYSICAL PAGE COORDINATES
      YL=(Y(1)-Y(N-1))/Y(N)
      XL=(X(1)-X(N-1))/X(N)
      RETURN
      END
"   END OF RECORD
```

BEST AVAILABLE COPY

```
 $INPUT IORPM=2$
   5
6 BLADES, STANDARD
           6    116.75        9.33         5.0         4.0     1.0133
      602.          13.         58.
      750.          22.         93.
      901.          30.        134.
     1050.          38.        186.
     1200.          54.        245.
           6    116.75        9.33        10.0         4.0     1.0133
      601.          26.        188.
      752.          37.        298.
      900.          56.        430.
     1050.          85.        601.
     1201.         121.        786.
           6    116.75        9.33        15.0         4.0     1.0133
      600.          36.        342.
      751.          61.        537.
      900.         104.        785.
     1051.         162.       1081.
     1200.         240.       1430.
99999
 $INPUT XMAX=120., YMAX=800.$
   3
2 SETS (6"SHRT,3"SHRT,NORM)
           6                               1.0
      630.           8.          2.
      902.          21.          5.
     1200.          39.         11.
           6                               5.0
      599.           9.         52.
      899.          25.        117.
     1200.          49.        217.
           6                              10.0
      599.          14.        155.
      899.          45.        358.
     1200.          98.        658.
    --- BLANK CARD ---
```

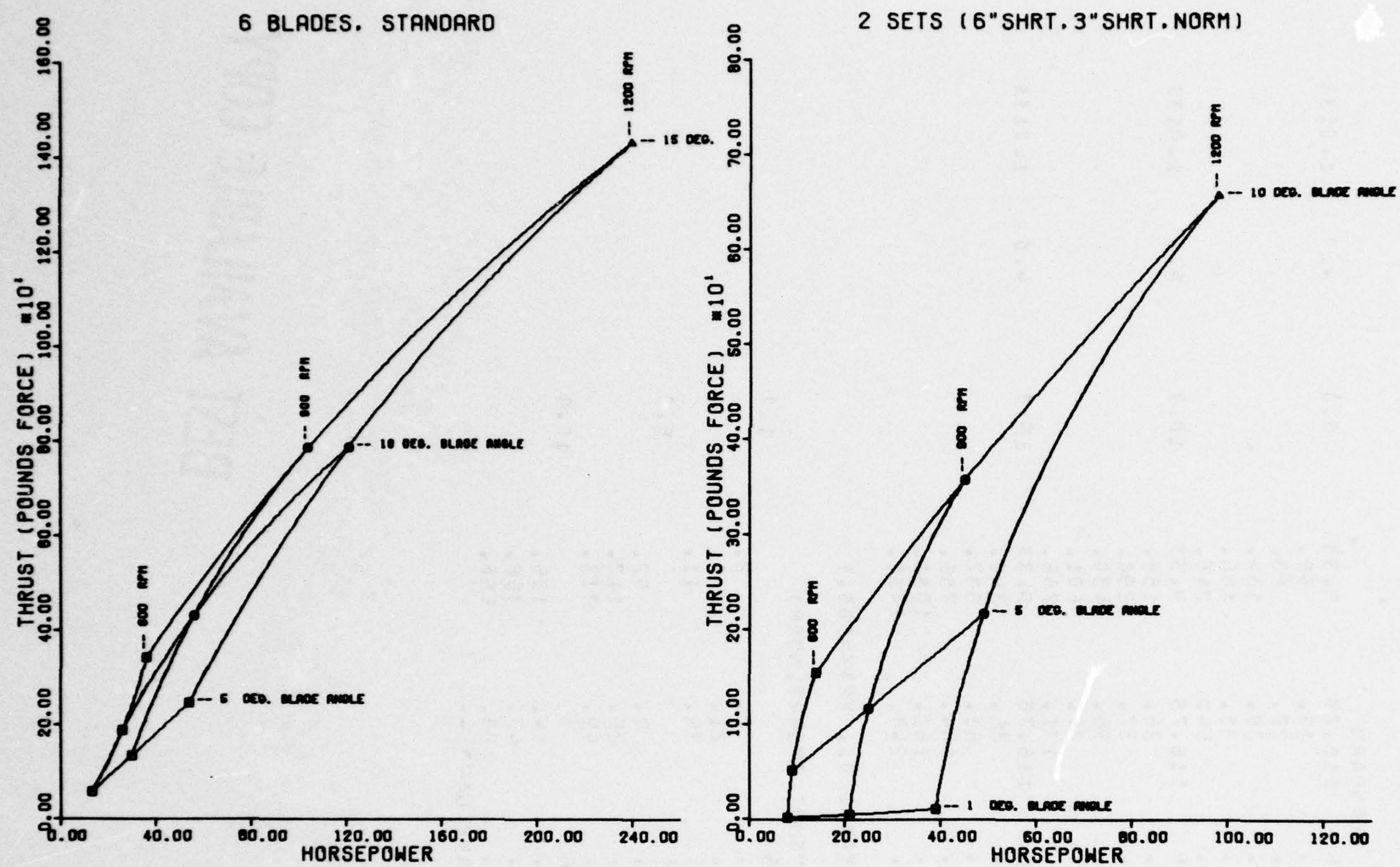


Figure B1-1: Plots From Sample HORSE Input Data Cards

APPENDIX B-2

PROGRAM THORSE

```
RM6,STCSA,CM77777,T40,IO80. P720119 MCGREGOR 55421
FTN,R=3.
MAP,PART.
ATTACH,PLOTLIB,OGIVEFILE,CY=2,ID=A740030,SN=ASD.
ATTACH,CCAUX,CCAUX,ID=X654321.
LIBRARY,CCAUX.
LOAD,LGO.
SATISFY.
LDSET,LIB=PLOTLIB.
SATISFY,PLOTLIB.
EXECUTE.
"  END OF RECORD
      PROGRAM THORSE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PLOT)
C *** THORSE IS USED TO PLOT THRUST/HORSEPOWER VS. HORSEPOWER FOR
C     VARIOUS QUIET PROPELLOR CONFIGURATIONS.  IT WILL ACCEPT DATA
C     WITH 3 OR 5 RPM POINTS.  ALL OR PART OF THE DATA MAY BE USED.
C
C    PRESET PARAMETERS (NAMELIST):
C        IORPM = (1) .. ALL AVAILABLE DATA USED IN PLOTS
C                 2  .. 3 RPM VALUES USED REGARDLESS OF DATA INPUT
C
C        YMIN = (3.) .. MINIMUM THRUST/HORSEPOWER FOR PLOT
C        YMAX = (11.) .. MAXIMUM THRUST/HORSEPOWER FOR PLOT
C        XMIN = (0.) .. MINIMUM HORSEPOWER FOR PLOT
C        XMAX = (240.) .. MAXIMUM HORSEPOWER FOR PLOT
C        RPM DATA POINTS (WRPM(1-5)) = 600.,750.,900.,1050.,1200.
C
C         * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C           NAMELIST FORMAT.  (EXAMPLE: $INPUT YMIN=6.,YMAX=24.$)
C
      INTEGER HEAD,ORD
      DIMENSION HEAD(40), BETA(3), X(2,3,5), CX(7), CY(7), WRPM(5)
     1,XC(102), YC(102), ORD(6), COEF(7)
      NAMELIST/INPUT/ WRPM,IORPM,YMIN,YMAX,XMIN,XMAX
      DATA WRPM/600.,750.,900.,1050.,1200./
      IORPM=1 $ YMIN=3. $ YMAX=11. $ XMIN=0. $ XMAX=240.
      CALL PLOT (0.,1.,-3)
    1 READ(5,INPUT)
      YSTEP=(YMAX-YMIN)/8.0
      XSTEP=(XMAX-XMIN)/6.0
C ** READ IN NUMBER OF RPM RUNS
    2 READ (5,8) NRPM
      IF (NRPM.EQ.0) GO TO 7
      IF(NRPM.EQ.99999) GO TO 1
      CALL READER (HEAD,BETA,X,Y,NRPM,0,IORPM,NSIZ,0)
      CALL CENTER (HEAD,40)
C ** SET UP AXIS FOR PLOTTING
      CALL AXIS (0.,0.,17HTHRUST/HORSEPOWER,17,8.,90.,YMIN,YSTEP)
      CALL AXIS (0.,0.,10HHORSEPOWER,-10,6.5,0.,XMIN,XSTEP)
      ENCODE(40,100,HEAD) HEAD
  100 FORMAT(40A1)
      CALL SYMBOL (0.50,8.35,0.15,HEAD,0.,40)
C ** SET UP DATA ARRAY FOR CONSTANT BLADE ANGLES
      DO 4 I=1,3
      DO 3 J=1,NSIZ
      CX(J)=X(1,I,J)
```

```
    3 CY(J)=X(2,I,J)/CX(J)
      IF(CY(NSIZ).LT.YMIN) GO TO 4
C ** DRAW A SMOOTH CURVE AND/OR DATA POINTS
      CALL CURVFT(CX,CY,NSIZ,XMIN,XSTEP,YMIN,YSTEP,-2,1,(I-1),1.,0.)
C ** DRAW LEGEND BY END OF LINE
      XL=(CX(NSIZ)-XMIN)/XSTEP
      YL=(CY(NSIZ)-YMIN)/YSTEP
      CALL SYMBOL ((XL+.1),YL,.08,22H--     DEG. BLADE ANGLE,0.,22)
      CALL NUMBER ((XL+.34),YL,0.08,BETA(I),0.,-1)
    4 CONTINUE
C ** SET UP DATA ARRAY FOR CONSTANT RPM'S
      DO 6 J=1,NSIZ
      DO 5 I=1,3
      CX(I)=X(1,I,J)
    5 CY(I)=X(2,I,J)/CX(I)
      M=3
      IF(CY(1).GE.YMIN) GO TO 50
      DO 40 K=1,4
      CX(K)=CX(K+1)
   40 CY(K)=CY(K+1)
      CX(3)=0.
      CY(3)=0.
      M=2
C ** PLOT POINTS AND DRAW A SMOOTH CURVE
   50 CALL CURVFT(CX,CY,M,XMIN,XSTEP,YMIN,YSTEP,-2,1,(J-1),1.,0.)
C ** DRAW LEGEND BY END OF LINE
      XL=(CX(M)-XMIN)/XSTEP
      YL=(CY(M)-YMIN)/YSTEP
      CALL SYMBOL (XL,(YL+.1),.08,11H--      RPM,90.,11)
C ** COMPUTE DESIRED INDEX FOR TITLE'S RPM VALUE
      LABEL=IFIX(FLOAT(J)*(5.0/FLOAT(NSIZ))+.001)
    6 CALL NUMBER (XL,(YL+.34),.08,WRPM(LABEL),90.,-1)
      CALL PLOT (9.5,0.,-3)
      GO TO 2
    7 CONTINUE
      CALL PLOTE
      STOP
C
    8 FORMAT (10I5)
      END
```

BEST AVAILABLE COPY

```
      SUBROUTINE READER (HEAD,BETA,X,Y,NRPM,NMIKE,IORPM,NSIZ,IODBA)
      DIMENSION HEAD(40), X(2,3,5), BETA(3)
      INTEGER HEAD
      READ (5,14) HEAD
      IF (IORPM.EQ.1) GO TO 9
      IF (IORPM.EQ.2.AND.NRPM.EQ.3) GO TO 9
C ** READ 3 POINTS IF 5 ARE AVAILABLE
      DO 2 I=1,3
      READ (5,15) BETA(I)
      DO 1 J=1,2
      READ (5,16) RPM,X(1,I,J),X(2,I,J)
    1 READ (5,16) TRASH
    2 READ (5,16) RPM,X(1,I,3),X(2,I,3)
      NSIZ=3
      GO TO 13
C ** READ ALL AVAILABLE DATA
    9 DO 10 I=1,3
      READ (5,15) BETA(I)
      DO 10 J=1,NRPM
   10 READ (5,16) RPM,X(1,I,J),X(2,I,J)
      NSIZ=NRPM
   13 RETURN
C
   14 FORMAT (40A1)
   15 FORMAT (30X,F10.3)
   16 FORMAT (3F10.3)
      END


      SUBROUTINE CENTER (HEAD,LENGTH)
C *** SUBROUTINE CENTER IS USED TO CENTER A HEADING WITHIN A VARIABLE-
C     LENGTH TITLE LINE
      INTEGER HEAD
      DIMENSION HEAD(LENGTH)
      INK=0
C ** COUNT THE RIGHT-HAND BLANKS
    1 LOC=LENGTH-INK
      IF (HEAD(LOC).NE.1H ) GO TO 2
      INK=INK+1
      GO TO 1
C ** PLACE HALF THE DETECTED BLANKS ON THE HEADING'S LEFT SIDE
    2 MOVE=IFIX(((FLOAT(INK))/2)+.001)
      IF(MOVE.EQ.0) RETURN
      DO 4 I=1,MOVE
      N=LENGTH-1
      IPOS=LENGTH+1
      DO 3 J=1,N
    3 HEAD(IPOS-J)=HEAD(LENGTH-J)
    4 HEAD(I)=1H
      RETURN
      END
"  END OF RECORD
```

BEST AVAILABLE COPY

```
 $INPUT $
    5
5 BLADES, STANDARD
           6     116.75        9.33        5.0        4.0     1.0133
      602.           13.          58.
      750.           22.          93.
      901.           30.         134.
     1050.           38.         186.
     1200.           54.         245.
           6     116.75        9.33       10.0        4.0     1.0133
      601.           26.         188.
      752.           37.         298.
      900.           56.         430.
     1050.           85.         601.
     1201.          121.         786.
           6     116.75        9.33       15.0        4.0     1.0133
      600.           36.         342.
      751.           61.         537.
      900.          104.         785.
     1051.          162.        1081.
     1200.          240.        1430.
99999
 $INPUT XMAX=120.$
    3
2 SETS (6"SHRT, 3"SHRT, NORM)
           6                               1.0
      630.            8.           2.
      902.           21.           5.
     1200.           39.          11.
           6                               5.0
      599.            9.          52.
      899.           25.         117.
     1200.           49.         217.
           6                              10.0
      599.           14.         155.
      899.           45.         358.
     1200.           98.         658.
   --- BLANK CARD ---
```

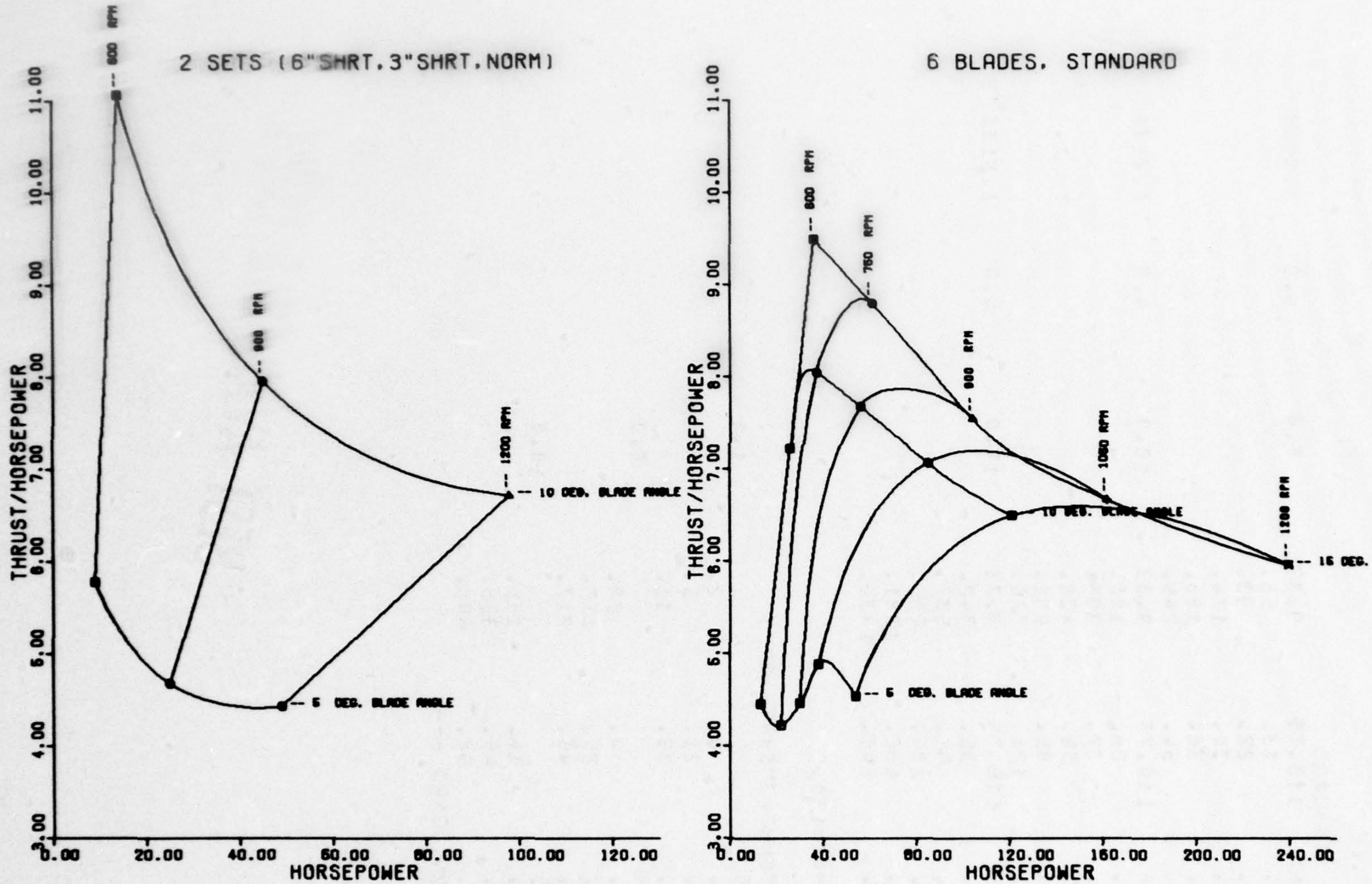
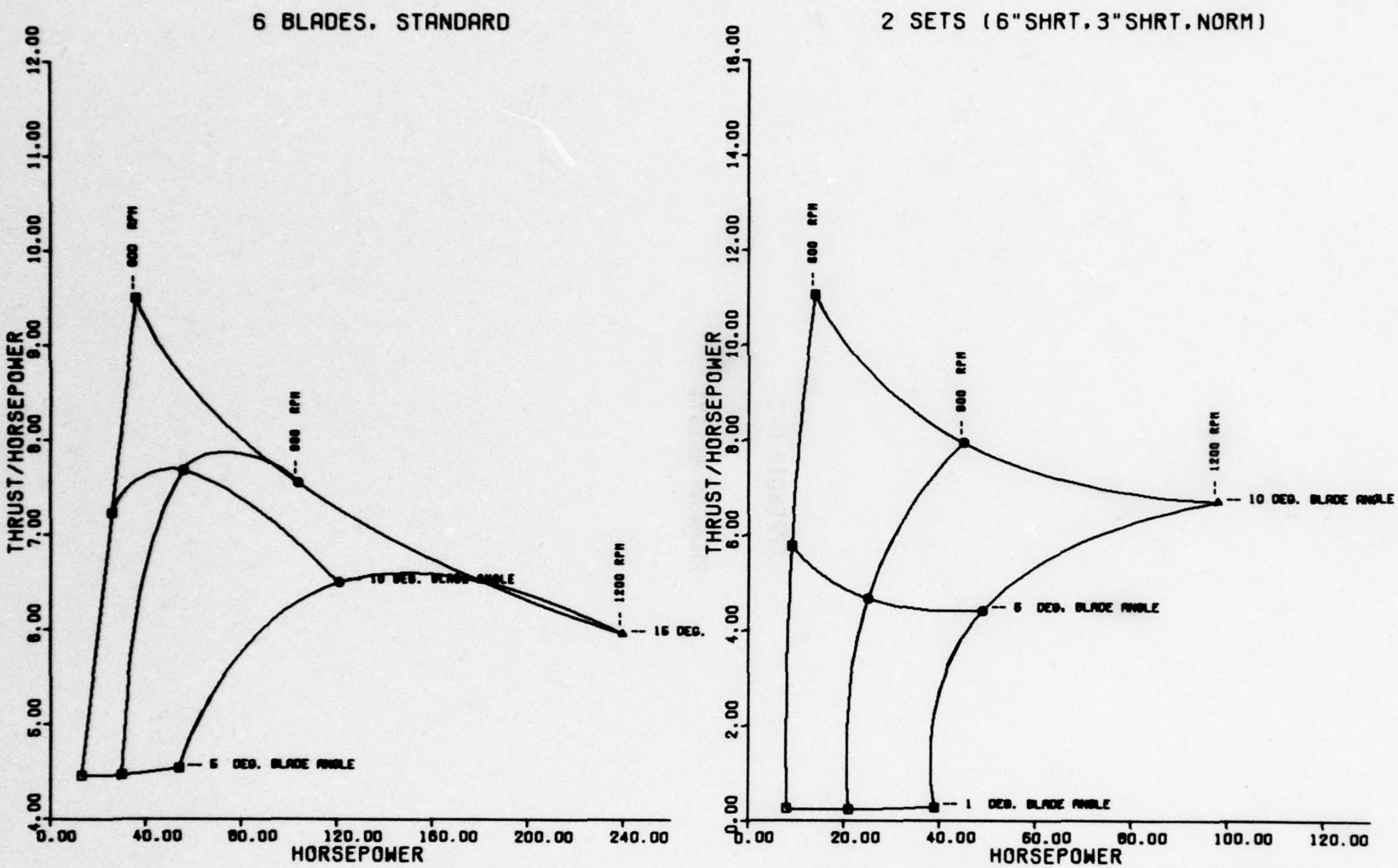


Figure B2-1: Plots From Sample THORSE Input Data Cards



$INPUT YMIN=4.,YMAX=12.,IORPM=2$ | **$INPUT XMAX=120.,YMIN=0.,YMAX=16$**

Figure B2-2: THORSE Output With Different $INPUT Card Sets

APPENDIX B-3

PROGRAM NOISY1

```
RM1,STCSA,CM55000,T20,IO20. P720119 MCGREGOR 52744
FTN,R=3.
MAP,PART.
ATTACH,CCAUX,CCAUX,ID=X654321.
LIBRARY,CCAUX.
LGO.
"   END OF RECORD
      PROGRAM NOISY1(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PLOT)
C
C     PROGRAM NOISY1 WILL PLOT THE SOUND PRESSURE LEVEL VS. FREQUENCY
C     PLUS THE OVERALL FOR ANY PROPELLOR RUNS.  THE USER MAY SPECIFY
C     THE DATA CARD FORMAT, THE OUTPUT PLOT RANGE, AND WHETHER OR NOT
C     HE DESIRES A DBA CURVE FOR EACH SPECTRA PLOTTED.  DEFAULT VALUES
C     ARE LISTED BELOW WITH INSTRUCTIONS FOR THEIR CHANGE.  DATA WILL
C     BE VARYING RPM RUNS FROM A SINGLE MICROPHONE.  (FOR A SINGLE
C     RPM FROM SEVERAL MICROPHONES, USE NOISY2)
C
C ****    PRESET PARAMETERS (NAMELIST)
C
C         DTFORM = (0) .. 3.15 THROUGH 20K PLUS OVERALL
C                   1  .. 20 THROUGH 20K PLUS OVERALL
C
C         IDBAST = (0) .. NORMAL PLOTS, NO ADDITIONAL DBA CURVE
C                   1 .. ADDITIONAL DBA CURVE DESIRED
C
C         SPLMIN =  (20.) .. MINIMUM SPL VALUE FOR PLOT
C         SPLMAX = (120.) .. MAXIMUM SPL VALUE FOR PLOT
C
C         START  = (1) .. STARTING FREQUENCY INDEX
C         FINISH = (28).. CLOSING FREQUENCY INDEX
C
C      INDEX TABLE
C      I  HZ      I    HZ      I   HZ      I    HZ      I   HZ      I    HZ
C      1  20      6    63     11  200     16   630     21  2000     26  6300
C      2  25      7    80     12  250     17   800     22  2500     27  8000
C      3  32      8   100     13  315     18  1000     23  3150     28 10000
C      4  40      9   125     14  400     19  1250     24  4000
C      5  50     10   150     15  500     20  1600     25  5000
C
C       * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C         NAMELIST FORMAT  (EXAMPLE: $INPUT FINISH=18, IDBAST=1$)
C
      INTEGER DTFORM,START,FINISH
      DIMENSION XFR(31)
      DIMENSION TITLEX(4),TITLEY(4),A(31),FR(30),TITLE(4),UNX(4),UNY(4)
      NAMELIST/INPUT/ DTFORM,IDBAST,START,FINISH,SPLMAX,SPLMIN
      DATA TITLEX/10HONE THIRD ,10HOCTAVE CEN,10HTER FREQUE,
     110HNCY IN HZ /,TITLEY/10HSOUND LEVE,10HLS IN DB R,10HE 0.0002 M,
     210HICROBAR   /,FR/20.,25.,31.5,40.,50.,63.,80.0,100.0,125.0,160.,
     3200.,250.,315.,400.,500.,630.,800.,1000.,1250.,1600.,2000.,2500.,
     43150.,4000.,5000.,6300.,8000.,10000.,10.,0.491/
     5,UNX/4.0,5.25,0.,1./,UNY/1.75,1.75,0.,1./
      DTFORM=0 $ IDBAST=0 $ START=1 $ FINISH=28 $ SPLMAX=120.
      SPLMIN=20.
      CALL PLOT(0.,1.,-3)
    5 READ(5,INPUT)
```

```
   10 READ(5,1000)TITLE,ICHNO
 1000 FORMAT (4A10,I10)
      IF(TITLE(1).EQ.10HNEWPARAM  ) GO TO 5
      IF(TITLE(1).EQ.10HENDDATA   )GO TO 999
      MM=START
      NN=FINISH
      CHNO=ICHNO
      SPLSTEP=(SPLMAX-SPLMIN)/8.0
      II=0
      YLOC=1.55
      NUMPTS=NN-MM+1
C**DRAW AND LABEL AXES
      CALL AXIS(0.,0.,TITLEY,40,8.,90.,SPLMIN,SPLSTEP)
      TINC=5.5/FLOAT(NUMPTS-1)
      TICK=0
      CALL PLOT(6.0,0.0,3)
      CALL PLOT(0.0,0.0,2)
      N=1
      DO 100 IPT=MM,NN
      IF(IPT.GT.2)N=-1
      CALL PLOT(TICK,-0.1,2)
      CALL NUMBER(TICK,-0.1,0.07,FR(IPT),-60.0,N)
      TICK=TICK+TINC
  100 CALL PLOT(TICK,0.0,3)
      CALL PLOT(6.0,0.0,3)
      CALL PLOT(6.0,-0.1,2)
      CALL SYMBOL(5.85,-0.2,0.1,3HO/A,0.0,3)
      CALL SYMBOL(.75,-.6,.1,44HONE-THIRD OCTAVE BAND CENTER FREQUENCY I
     2N HZ,0.0,44)
      CALL SYMBOL(1.35,8.35,0.1,TITLE,0.,40)
      CALL SYMBOL(2.05,8.5,0.15,11HMIKE NUMBER,0.,11)
      CALL NUMBER (3.85,8.5,0.15,CHNO,0.,-1)
      CALL SYMBOL(4.5,1.775,0.1,3HRPM,0.,3)
      CALL LINE(UNX,UNY,2,1,0,0)
C**PUT DATA IN A ARRAY
  200 READ(5,1001)IRUNNO
      RUNNO=IRUNNO
      IDBA=IDBAST
 1001 FORMAT(I10)
      IF(IRUNNO.EQ.0)GO TO 899
      CALL GETIN(DTFORM,IRUNNO,ICHNO,A,MM,NN)
C**PUT IN SYMBOL FOR OVERALL SPL
 1002 OALL=OVERAL(A,MM,NN)
      WRITE(6,2000)OALL
 2000 FORMAT(F10.4)
      OALL=(OALL-SPLMIN)/SPLSTEP
      CALL SYMBOL(6.00,OALL,0.1,II,0.0,-1)
      CALL SYMBOL(4.35,YLOC+.05,0.1,II,0.,-1)
      CALL NUMBER(4.7,YLOC,0.1,RUNNO,0.,-1)
      IF(IDBAST.EQ.0.OR.IDBA.EQ.1) GO TO 249
      CALL SYMBOL(5.25,YLOC,0.1,5H(DBA),0.,5)
C**REMOVE OUT-OF RANGE-POINTS
  249 DO 300 JJ=1,NUMPTS
      IF (A(JJ).GE.SPLMIN) GO TO 250
      A(JJ)=3.125+SPLMIN
  250 IF (A(JJ).LE.SPLMAX) GO TO 300
```

```
      A(JJ)=SPLMAX-3.125
  300 CONTINUE
C**DRAW EACH LINE
      A(NUMPTS+1)=SPLMIN
      A(NUMPTS+2)=SPLSTEP
      XFR(NUMPTS+1)=0
      XFR(NUMPTS+2)=1.
      JJ=MM
      DO 201 I=1,NUMPTS
      XFR(I)=TINC*FLOAT(I-1)
201   CONTINUE
      CALL LINE(XFR,A,NUMPTS,1,1,II)
      YLOC=YLOC-0.15
      II=II+1
      IF (IDBA.NE.1) GO TO 799
      CALL DBALIN(A,MM,NN)
      IDBA=IDBA-1
      GO TO 1002
  799 CONTINUE
      GO TO 200
  899 CALL PLOT(8.5,0.0,-3)
      GO TO 10
  999 CONTINUE
      CALL PLOTE
      STOP
      END


      SUBROUTINE GETIN(K,IRUNNO,ICHNO,A,MM,NN)
      DIMENSION A(31)
      IF (K.EQ.1) GO TO 50
      READ(5,1000)(A(L),L=1,2)
      READ(5,1001)(A(L),L=3,12)
      READ(5,1001)(A(L),L=13,22)
      READ(5,1003) (A(L),L=23,28)
 1000 FORMAT(62X,2F6.1)
 1001 FORMAT(10F6.1)
 1003 FORMAT(6F6.1)
      GO TO 75
   50 READ (5,2000)  (A(L),L=1,10)
      READ (5,1001)  (A(L),L=11,20)
      READ (5,2001)  (A(L),L=21,28)
      READ (5,2002) GARBAGE
 2000 FORMAT  (16X,10F6.1)
 2001 FORMAT  (8F6.1)
 2002 FORMAT(F6.1)
   75 WRITE  (6,200)
      WRITE(6,100)(A(L),L=MM,NN)
  100 FORMAT(1H ,10E12.2)
  200 FORMAT  (2X,10HDB *******)
      RETURN
      END
```

```
      SUBROUTINE DBALIN(A,MM,NN)
      DIMENSION A(31),DBAWT(28)
      DATA DBAWT/-50.5,
     A-44.7,-39.4,-34.6,-30.2,-26.2,-22.5,-19.1,-16.1,-13.4,-10.9,-8.6,
     B-6.6,-4.8,-3.2,-1.9,-0.8,0.0,0.6,1.0,1.2,1.3,1.2,1.0,0.5,-0.1,
     C-1.1,-2.5/
      DO 100 I=1,28
  100 A(I)=A(I)+DBAWT(I)
      WRITE (6,200)
      WRITE (6,300)  (A(L),L=MM,NN)
  200 FORMAT (2X,10HDBA ******)
  300 FORMAT (1H ,10E12.2)
      RETURN
      END
"  END OF RECORD
```

```
      FUNCTION OVERAL(A,MM,NN)
      DIMENSION A(31)
      SUM=0.0
      DO 100 I=MM,NN
  100 SUM=SUM+(10.0**(A(I)/10.0))
      OVERAL=10.0*ALOG10(SUM)
      RETURN
      END
```

```
 $INPUT DTFORM=1, IDBAST=1$
6 BLADE BASELINE - 15 DEGREE PITCH                      3
     900
ID: %+R003 C003$ 050.7 054.5 057.5 062.2 064.7 068.2 079.2 082.5 068.2 073.0
 075.7 075.5 074.2 079.5 079.5 080.0 080.5 080.5 081.5 080.7
 081.2 081.5 084.0 083.0 081.7 084.0 084.7 089.0 062.5 048.7
 044.0 094.5
   --- BLANK CARD ---
ENDDATA
```

BEST AVAILABLE COPY

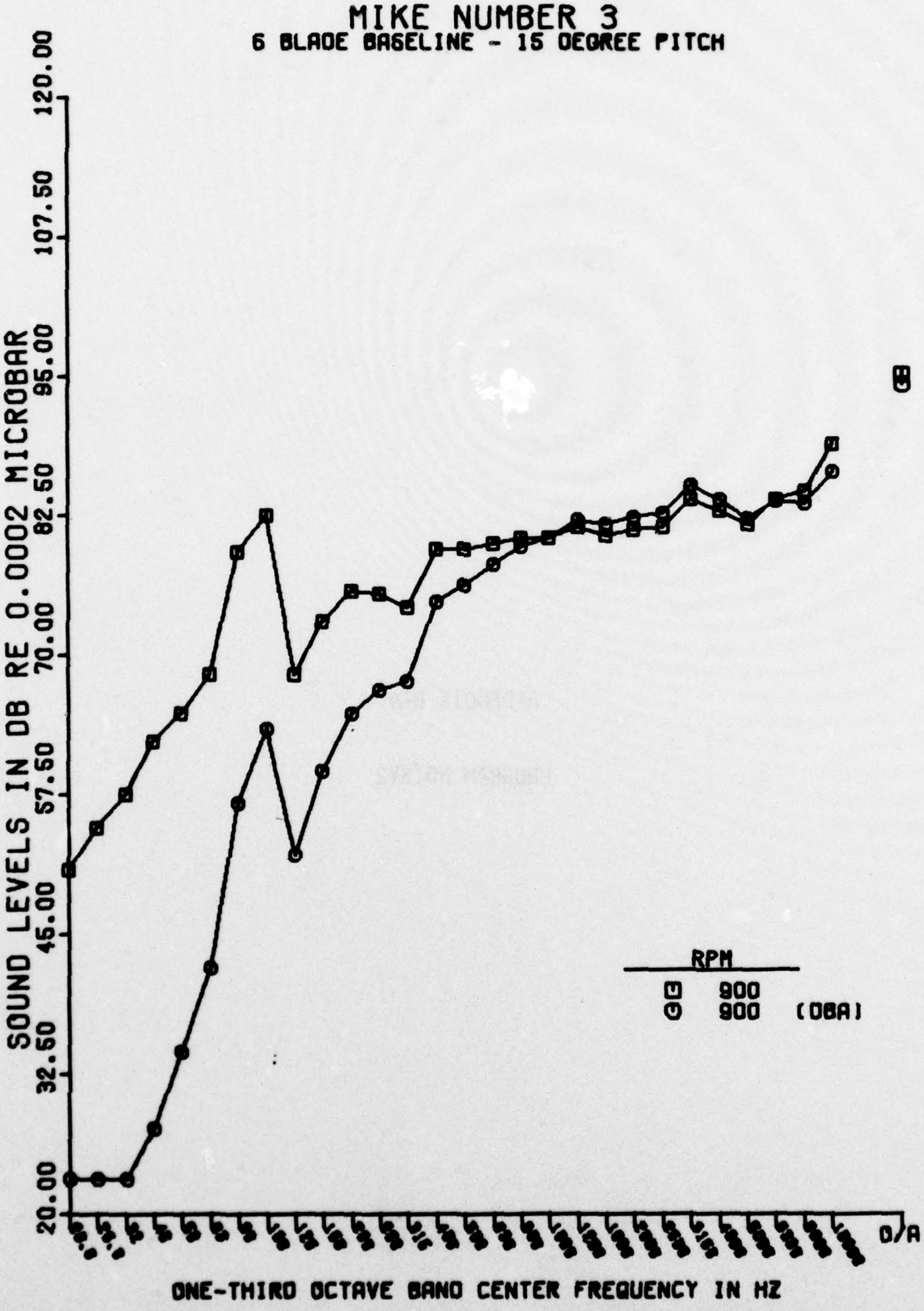


Figure B3-1: Plot From Sample NOISY1 Input Data Cards

APPENDIX B-4

PROGRAM NOISY2

```
MAC,STCSA,CM60000,T40,IO80. P720119 MCGREGOR 55421
FTN.
ATTACH,CCAUX,CCAUX,ID=X654321.
LIBRARY,CCAUX.
LGO.
"  END OF RECORD
      PROGRAM NOISY2(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PLOT)
C
C     PROGRAM NOISY2 WILL PLOT THE SOUND PRESSURE LEVEL VS. FREQUENCY
C     PLUS THE OVERALL FOR ANY PROPELLOR RUNS.  THE USER MAY SPECIFY
C     THE DATA CARD FORMAT, THE OUTPUT PLOT RANGE, AND WHETHER OR NOT
C     HE DESIRES A DBA CURVE FOR EACH SPECTRA PLOTTED.  DEFAULT VALUES
C     ARE LISTED BELOW WITH INSTRUCTIONS FOR THEIR CHANGE.  DATA WILL
C     BE A CONSTANT RPM FROM ANY NUMBER OF MICROPHONES.  (FOR A
C     SINGLE MICROPHONE AND VARYING RPM'S, USE NOISY1)
C
C ****    PRESET PARAMETERS (NAMELIST)
C
C         DTFORM = (0) .. 3.15 THROUGH 20K PLUS OVERALL
C                   1  .. 20 THROUGH 20K PLUS OVERALL
C
C         IDBAST = (0) .. NORMAL PLOTS, NO ADDITIONAL DBA CURVE
C                   1  .. ADDITIONAL DBA CURVE DESIRED
C
C         SPLMIN =  (20.) .. MINIMUN SPL VALUE FOR PLOT
C         SPLMAX = (120.) .. MAXIMUM SPL VALUE FOR PLOT
C
C         START  = (1) .. STARTING FREQUENCY INDEX
C         FINISH = (28).. CLOSING FREQUENCY INDEX
C
C       INDEX TABLE
C       I   HZ       I    HZ      I   HZ      I   HZ        I    HZ       I    HZ
C       1   20       6    63     11  200     16   630      21  2000      26  6300
C       2   25       7    80     12  250     17   800      22  2500      27  8000
C       3   32       8   100     13  315     18  1000      23  3150      28 10000
C       4   40       9   125     14  400     19  1250      24  4000
C       5   50      10   150     15  500     20  1600      25  5000
C
C        * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C          NAMELIST FORMAT  (EXAMPLE: $INPUT FINISH=18, IDBAST=1$)
C
      INTEGER DTFORM,START,FINISH
      DIMENSION XFR(31)
      DIMENSION TITLEX(4),TITLEY(4),A(31),FR(30),TITLE(4),UNX(4),UNY(4)
      NAMELIST/INPUT/ DTFORM,IDBAST,START,FINISH,SPLMAX,SPLMIN
      DATA TITLEX/10HONE THIRD ,10HOCTAVE CEN,10HTER FREQUE,
     110HNCY IN HZ /,TITLEY/10HSOUND LEVE,10HLS IN DB R,10HE 0.0002 M,
     210HICROBAR   /,FR/20.,25.,31.5,40.,50.,63.,80.0,100.0,125.0,150.,
     3200.,250.,315.,400.,500.,630.,800.,1000.,1250.,1600.,2000.,2500.,
     43150.,4000.,5000.,6300.,8000.,10000.,10.,0.491/
     *,UNX/3.8,5.65,0.,1./,UNY/8.0,8.0,0.,1./
      DTFORM=0 $ IDBAST=0 $ START=1 $ FINISH=28 $ SPLMAX=120.
      SPLMIN=20.
      CALL PLOT(0.,1.,-3)
    5 READ(5,INPUT)
   10 READ(5,1000)TITLE,IRPMO
```

```
 1000 FORMAT (4A10,I10)
      IF(TITLE(1).EQ.10HNEWPARAM  ) GO TO 5
      IF(TITLE(1).EQ.10HENDDATA   )GO TO 999
      RPMO=IRPMO
      IDBA=IDBAST
      II=0
      YLOC=7.75
      MM=START
      NN=FINISH
      NUMPTS=NN-MM+1
C**DRAW AND LABEL AXES
      SPLSTEP=(SPLMAX-SPLMIN)/8.0
      CALL AXIS(0.,0.,TITLEY,40,8.,90.,SPLMIN,SPLSTEP)
      TINC=5.5/FLOAT(NUMPTS-1)
      TICK=0
      CALL PLOT(6.0,0.0,3)
      CALL PLOT(0.0,0.0,2)
      N=1
      DO 100 IPT=MM,NN
      IF(IPT.GT.2)N=-1
      CALL PLOT(TICK,-0.1,2)
      CALL NUMBER(TICK,-0.1,0.07,FR(IPT),-60.0,N)
      TICK=TICK+TINC
  100 CALL PLOT(TICK,0.0,3)
      CALL PLOT(6.0,0.0,3)
      CALL PLOT(6.0,-0.1,2)
      CALL SYMBOL(5.85,-0.2,0.1,3HO/A,0.0,3)
      CALL SYMBOL(.75,-.6,.1,44HONE-THIRD OCTAVE BAND CENTER FREQUENCY I
     2N HZ,0.0,44)
      CALL SYMBOL(0.0,8.5,0.15,TITLE,0.0,40 )
      CALL SYMBOL(3.9,7.75,0.10,11HMIKE NUMBER,0.0,11)
      CALL SYMBOL(4.875,8.025,0.1,3HRPM,0.,3)
      CALL NUMBER(4.375,8.025,0.1,RPMO,0.,-1)
      CALL LINE(UNX,UNY,2,1,0,0)
C**PUT DATA IN A ARRAY
  200 READ(5,1001)IMIKO
      XMIKO=IMIKO
 1001 FORMAT(I10)
      IF(IMIKO.EQ.0) GO TO 899
      CALL GETIN(DTFORM,IRUNNO,ICHNO,A,MM,NN)
C**PUT IN SYMBOL FOR OVERALL SPL
 1002 OALL=OVERAL(A,MM,NN)
      WRITE(6,2000)OALL
 2000 FORMAT(F10.4)
      OALL=(OALL-SPLMIN)/SPLSTEP
      CALL SYMBOL(6.00,OALL,0.1,II,0.0,-1)
      CALL SYMBOL(5.5,YLOC+.05,0.10,II,0.0,-1)
      CALL NUMBER(5.1,YLOC,0.10,XMIKO,0.0,-1)
      IF(IDBAST.EQ.0.OR.IDBA.EQ.1) GO TO 249
      CALL SYMBOL(5.75,YLOC,0.1,5H(DBA),0.,5)
C**REMOVE OUT-OF RANGE-POINTS
  249 DO 300 JJ=1,NUMPTS
      IF (A(JJ).GE.SPLMIN) GO TO 250
      A(JJ)=3.125+SPLMIN
  250 IF (A(JJ).LE.SPLMAX) GO TO 300
      A(JJ)=SPLMAX-3.125
```

```
  300 CONTINUE
C**DRAW EACH LINE
      A(NUMPTS+1)=SPLMIN
      A(NUMPTS+2)=SPLSTEP
      XFR(NUMPTS+1)=0
      XFR(NUMPTS+2)=1.
      JJ=MM
      DO 201 I=1,NUMPTS
      XFR(I)=TINC*FLOAT(I-1)
201   CONTINUE
      CALL LINE(XFR,A,NUMPTS,1,1,II)
      YLOC=YLOC-0.15
      II=II+1
      IF (IDBA.NE.1) GO TO 799
      CALL DBALIN(A,MM,NN)
      IDBA=IDBA-1
      GO TO 1002
  799 CONTINUE
      GO TO 200
  899 CALL PLOT(8.5,0.0,-3)
      GO TO 10
  999 CONTINUE
      CALL PLOTE
      STOP
      END



      SUBROUTINE GETIN(K,IRUNNO,ICHNO,A,MM,NN)
      DIMENSION A(31)
      IF (K.EQ.1) GO TO 50
      READ(5,1000)(A(L),L=1,2)
      READ(5,1001)(A(L),L=3,12)
      READ(5,1001)(A(L),L=13,22)
      READ(5,1003) (A(L),L=23,28)
 1000 FORMAT(62X,2F6.1)
 1001 FORMAT(10F6.1)
 1003 FORMAT(6F6.1)
      GO TO 75
   50 READ (5,2000)  (A(L),L=1,10)
      READ (5,1001)  (A(L),L=11,20)
      READ (5,2001)  (A(L),L=21,28)
      READ (5,2002) GARBAGE
 2000 FORMAT (16X,10F6.1)
 2001 FORMAT (8F6.1)
 2002 FORMAT(F5.1)
   75 WRITE (6,200)
      WRITE(6,100)(A(L),L=MM,NN)
  100 FORMAT(1H ,10E12.2)
  200 FORMAT (2X,10HDB *******)
      RETURN
      END
```

```
      FUNCTION OVERAL(A,MM,NN)
      DIMENSION A(31)
      SUM=0.0
      DO 100 I=MM,NN
  100 SUM=SUM+(10.0**(A(I)/10.0))
      OVERAL=10.0*ALOG10(SUM)
      RETURN
      END
```

```
      SUBROUTINE DBALIN(A,MM,NN)
      DIMENSION A(31),DBAWT(28)
      DATA DBAWT/-50.5,
     A-44.7,-39.4,-34.6,-30.2,-26.2,-22.5,-19.1,-16.1,-13.4,-10.9,-8.6,
     B-6.6,-4.8,-3.2,-1.9,-0.8,0.0,0.6,1.0,1.2,1.3,1.2,1.0,0.5,-0.1,
     C-1.1,-2.5/
      DO 100 I=1,28
  100 A(I)=A(I)+DBAWT(I)
      WRITE (6,200)
      WRITE (6,300) (A(L),L=MM,NN)
  200 FORMAT (2X,10HDBA ******)
  300 FORMAT (1H ,10F12.2)
      RETURN
      END
 "  END OF RECORD
```

```
 $INPUT SPLMIN=40., FINISH=25$
6 BLADE, 10% MOD - 10 DEGREE PITCH                    900
        3
ID: R013 C003$ 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0 048.0 048.5
 049.7 051.0 055.0 062.7 076.5 079.0 064.2 072.7 075.0 074.0
 075.0 075.7 076.2 076.7 075.7 075.7 076.2 076.2 076.5 076.5
 078.7 079.7 083.5 086.7 087.0 089.7 054.7 044.0 044.0 094.2
        9
ID: R013 C009$ 049.0 049.0 049.0 049.0 049.0 049.0 049.0 049.0 050.0 050.2
 053.0 053.2 056.7 064.2 078.0 081.2 073.5 084.2 083.7 084.5
 087.5 090.0 090.1 090.2 088.5 088.2 087.5 085.0 084.7 084.7
 087.2 091.5 094.2 094.7 099.5 095.0 052.5 049.0 049.0 103.7
   --- BLANK CARD ---
ENDDATA
```

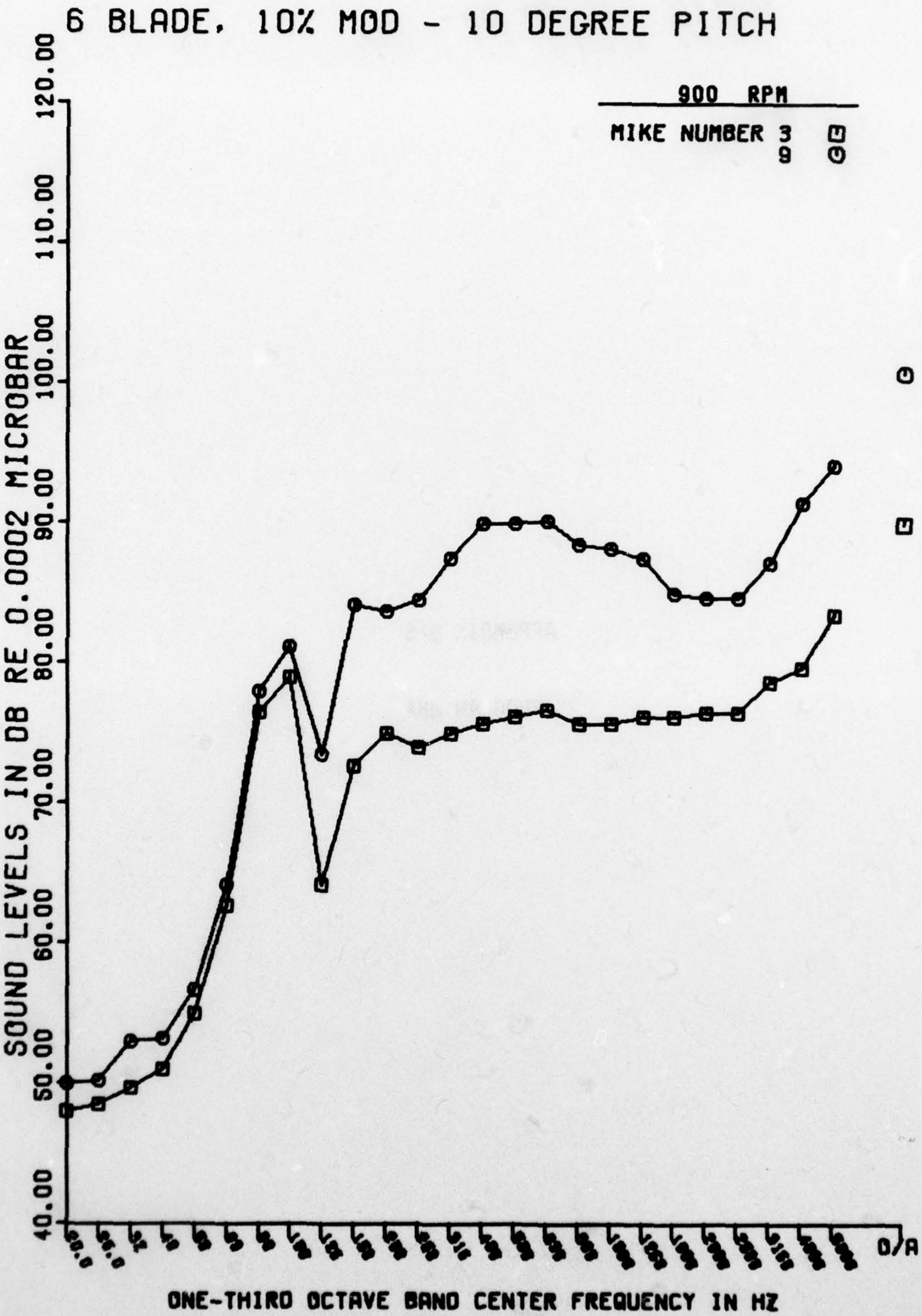


Figure B4-1: Plot From Sample NOISY2 Input Data Cards

APPENDIX B-5

PROGRAM dBA

```
RM8,STCSA,CM60000,T40,IO30. P720119 MCGREGOR 55421
FTN.
LGO.
"   END OF RECORD
      PROGRAM DBA (INPUT,OUTPUT,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7=PUN
     1CH)
      INTEGER INFO,FRQRNG
      REAL JUNK
      DIMENSION INFO(8), DBAWT(39), DB(2,40), IMIKE(12)
      NAMELIST/INPUT/ IPUNCH
      DATA DBAWT/-80.0,-80.0,-80.0,-80.0,-80.0,-70.4,-63.4,-56.7,-50.5,-
     144.7,-39.4,-34.6,-30.2,-26.2,-22.5,-19.1,-16.1,-13.4,-10.9,-8.6,-6
     2.6,-4.8,-3.2,-1.9,-0.8,0.0,0.6,1.0,1.2,1.3,1.2,1.0,0.5,-0.1,-1.1,-
     32.5,-4.3,-6.6,-9.3/
    1 CONTINUE
C     PROGRAM DBA IS USED TO CALCULATE BOTH DB AND DBA WEIGHTED SOUND
C     LEVELS FOR ANY SET OF DATA TAKEN ON THE QUIET PROPELLER RUNS.
C     THE USER MUST SPECIFY THE NUMBER OF RPM RUNS PER CONFIGURATION AND
C     THE NUMBER OF MICROPHONES INCLUDED IN THE DATA.  TWO DATA FORMATS
C     MAY BE READ, DEPENDING ON THE ORIGINAL PUNCHED CARDS. THE MAIN
C     OPTIONS INCLUDE CONSIDERATION OF ONLY DESIRED MICROPHONES, AND
C     THEN ONLY OVER THE SPECIFIED RANGE OF FREQUENCIES.  THE USER MAY
C     SPECIFY THE INTERNAL PROGRAM OPTION, IPUNCH, TO GIVE ONLY THE
C     PRINTOUT AND NO CARDS.  CARDS PRODUCED BY THIS PROGRAM WILL CONTAIN
C     THE DB AND DBA LEVELS, THE RUN IDENTIFICATION, AND THE RANGE
C     CONSIDERED IN THE CALCULATIONS.  DATA CARD ORDERING IS GIVEN BELOW
C
C     *** SPECIFICATION DATA CARDS ***
C            NRUN   = NUMBER OF DIFFERENT RPMS/CONFIGURATION        I5
C            NCHANL = NUMBER OF MICROPHONE CHANNELS/RPM RUN         I5
C            NMIKE  = TOTAL NUMBER OF DESIRED MICROPHONES           I5
C            IMIKE  = MICROPHONE IDENTIFICATION NUMBERS           10I5
C            FRQRNG = DATA CARD FREQUENCY RANGE CODE                I5
C                        1 .. 3.15 HZ TO 20K HZ
C                        2 .. 20 HZ TO 20K HZ
C            NN,MM  = RANGE TO BE CONSIDERED IN CALCULATIONS       2I5
C                        NN = 8 + INDEX OF STARTING FREQUENCY
C                        MM = 8 + INDEX OF FINAL FREQUENCY
C       INDEX TABLE
C       I  HZ       I    HZ     I   HZ     I    HZ     I    HZ     I    HZ
C       1  20       6    63    11  200    16   630    21  2000    26  6300
C       2  25       7    80    12  250    17   800    22  2500    27  8000
C       3  32       8   100    13  315    18  1000    23  3150    28 10000
C       4  40       9   125    14  400    19  1250    24  4000
C       5  50      10   150    15  500    20  1600    25  5000
C
C ****    PRESET PARAMETERS (NAMELIST)
C         IPUNCH =  0  .. NO PUNCHED DATA DESIRED
C                  (1) .. PUNCHED DATA DESIRED
C
C       * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C         NAMELIST FORMAT  (EXAMPLE: $INPUT IPUNCH=0$)
C
      IPUNCH=1
      READ(5,INPUT)
      READ (5,19) NRUN
```

```
      READ (5,19) NCHANL
      READ (5,19) NMIKE
      READ (5,20) (IMIKE(II),II=1,NMIKE)
      READ (5,19) FRQRNG
      READ (5,21) NN,MM
C
      NSTRT=NMIKE+1
      DO 2 JJ=NSTRT,12
    2 IMIKE(JJ)=99
      TLDBA=0.0
    3 READ (5,22) (INFO(II),II=1,8)
      IF (INFO(1).EQ.10HRESTART   ) GO TO 1
      WRITE (6,23) (INFO(II),II=1,8)
      IF (IPUNCH.EQ.0) GO TO 4
      WRITE (7,22) (INFO(II),II=1,8)
    4 IF (INFO(1).EQ.10H          ) STOP
      DO 18 L=1,NRUN
      ISTEP=1
      DO 18 I=1,NCHANL
      IF (FRQRNG.EQ.1) GO TO 6
      DO 5 NMN=1,8
    5 DB(NMN)=0.0
      READ (5,25) IDRUN,IDMIKE,(DB(1),N=9,18)
      GO TO 7
    6 READ (5,24) IDRUN,IDMIKE,(DB(1,N),N=1,10)
    7 CONTINUE
      IF (IDMIKE.EQ.IMIKE(ISTEP)) GO TO 9
      DO 8 JJ=1,3
    8 READ (5,26) JUNK
      GO TO 18
    9 ISTEP=ISTEP+1
      IF (FRQRNG.EQ.1) GO TO 10
      READ (5,27) (DB(1,N),N=19,28)
      READ (5,27) (DB(1,N),N=29,38)
      READ (5,27) (DB(1,N),N=39,40)
      GO TO 11
   10 READ (5,27) (DB(1,N),N=11,20)
      READ (5,27) (DB(1,N),N=21,30)
      READ (5,27) (DB(1,N),N=31,40)
   11 CONTINUE
      DO 12 J=NN,MM
   12 DB(2,J)=DB(1,J)+DBAWT(J)
      DO 14 K=1,2
      DO 13 J=NN,MM
   13 TLDBA=TLDBA+(10.**(DB(K,J)/10.))
      DB(K,40)=10.*(ALOG10(TLDBA))
   14 TLDBA=0.0
      IF (FRQRNG.EQ.1) GO TO 15
      WRITE (6,28) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
      GO TO 16
   15 WRITE (6,29) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
   16 IF (IPUNCH.EQ.0) GO TO 18
      IF (FRQRNG.EQ.1) GO TO 17
      WRITE (7,28) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
      GO TO 18
   17 WRITE (7,29) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
```

```
    18 CONTINUE
       GO TO 3
C
    19 FORMAT (I5)
    20 FORMAT (10I5)
    21 FORMAT (2I5)
    22 FORMAT (8A10)
    23 FORMAT (1H1,///,8A10,/)
    24 FORMAT (6X,I2,3X,I2,1X,10F6.1)
    25 FORMAT (3X,I2,3X,I2,1X,10F6.1)
    26 FORMAT (F6.1)
    27 FORMAT (10F6.1)
    28 FORMAT (2F10.2,30X,8HID: %+R0,I2,3H C0,I2,3H$   ,2I5)
    29 FORMAT (2F10.2,30X,6HID: R0,I2,3H C0,I2,3H$   ,2I5)
       END
"   END OF RECORD
```

```
$INPUT $
   6
  10
   4
   3    4    9   10
   2
   9   36
***** 6-BLADE BASELINE, 10 DEGREE PITCH *******************************************
ID: %+R006 C001$ 047.7 049.0 054.0 058.2 077.0 090.5 065.7 066.0 079.2 063.2
 066.0 067.0 067.2 070.2 070.2 072.0 072.5 072.2 072.0 071.5
 073.0 075.0 081.0 086.0 082.7 083.2 085.7 079.7 044.0 044.0
 044.0 094.0
ID: %+R006 C002$ 042.5 042.0 047.2 047.2 061.2 074.5 053.0 053.5 061.2 059.0
 062.5 064.7 064.7 067.5 067.2 068.7 069.2 069.5 068.2 068.7
 069.7 072.0 080.0 083.7 079.7 085.0 084.7 077.2 039.7 038.0
 038.0 090.2
ID: %+R006 C003$ 042.5 041.5 048.2 043.2 049.0 057.7 048.5 052.7 061.0 056.0
 059.7 062.0 060.7 062.7 063.2 065.0 064.2 064.2 063.2 063.2
 064.0 066.5 073.7 079.0 076.2 081.0 078.5 070.7 034.5 034.0
 034.0 085.0
ID: %+R006 C004$ 039.2 040.7 052.0 043.0 048.2 057.7 048.2 047.7 055.0 052.7
 056.0 057.7 058.7 061.0 059.7 062.5 062.2 062.2 061.2 060.7
 061.2 064.2 071.7 076.7 073.0 077.0 074.5 066.0 029.5 029.
 029.0 082.0
```

....

200 SIMILAR CARDS REMOVED TO SHORTEN LISTING

....

```
ID: %+R011 C005$ 060.2 056.0 054.0 057.0 058.5 071.0 064.0 071.7 069.7 077.2
 078.5 091.2 082.0 093.2 091.0 091.0 090.2 090.5 090.5 089.5
 089.2 088.2 089.2 089.5 092.2 094.7 097.7 100.0 067.5 057.
 054.0 104.5
ID: %+R011 C006$ 064.2 059.2 055.0 061.0 060.0 064.0 065.0 073.7 092.5 078.5
 078.5 094.0 082.2 091.7 089.0 089.7 089.2 090.5 089.7 089.2
 089.2 087.7 088.2 088.5 090.5 093.7 096.7 098.0 065.5 055.7
 053.0 103.5
ID: %+R011 C007$ 068.0 069.7 071.7 075.0 075.0 080.0 081.0 088.0 101.0 093.5
 093.7 098.2 092.2 105.0 099.7 104.5 101.5 103.5 102.5 101.0
 098.7 097.2 098.0 101.0 105.2 106.7 103.0 110.7 078.7 064.0
 064.0 115.0
ID: %+R011 C008$ 066.5 065.0 065.5 070.2 068.7 076.2 075.7 083.7 100.2 090.7
 089.7 097.2 090.0 103.7 102.2 101.7 101.7 101.7 100.2 098.7
 097.2 096.2 097.5 098.0 103.0 107.2 102.5 109.0 079.0 064.0
 064.0 114.0
ID: %+R011 C009$ 058.0 058.0 058.0 064.2 062.2 069.7 070.5 079.7 098.5 088.0
 085.0 096.7 087.2 099.5 098.7 099.2 097.7 099.5 097.2 096.2
 095.2 095.7 096.2 095.0 099.2 104.0 099.2 103.7 074.0 058.0
 058.0 110.5
ID: %+R011 C010$ 056.0 056.0 056.0 060.2 058.7 069.0 070.2 074.2 091.7 081.0
 080.7 095.2 084.2 095.2 092.7 094.2 094.2 093.5 092.2 092.0
 091.7 091.7 091.5 091.0 093.0 098.2 094.0 098.0 067.0 056.0
 056.0 105.2
   --- BLANK CARD ---
```

```
***** 6-BLADE BASELINE, 10 DEGREE PITCH ****************************************
    85.80       85.86                              ID: %+R0 6 C0 3$        9    36
    82.53       82.73                              ID: %+R0 6 C0 4$        9    36
    93.13       93.22                              ID: %+R0 6 C0 9$        9    36
    88.23       88.30                              ID: %+R0 6 C010$        9    36
    91.09       90.59                              ID: %+R0 7 C0 3$        9    36
    87.25       86.88                              ID: %+R0 7 C0 4$        9    36
    99.70       99.00                              ID: %+R0 7 C0 9$        9    36
    94.95       93.99                              ID: %+R0 7 C010$        9    36
    94.87       94.26                              ID: %+R0 8 C0 3$        9    36
    90.71       90.16                              ID: %+R0 8 C0 4$        9    36
   103.53      102.88                              ID: %+R0 8 C0 9$        9    36
    97.95       97.39                              ID: %+R0 8 C010$        9    36
    96.67       95.91                              ID: %+R0 9 C0 3$        9    36
    93.02       92.37                              ID: %+R0 9 C0 4$        9    36
   107.38      106.47                              ID: %+R0 9 C0 9$        9    36
   101.64      100.81                              ID: %+R0 9 C010$        9    36
   100.41       99.24                              ID: %+R010 C0 3$        9    36
    96.87       95.84                              ID: %+R010 C0 4$        9    36
   109.93      109.04                              ID: %+R010 C0 9$        9    36
   104.42      103.61                              ID: %+R010 C010$        9    36
   103.65      101.55                              ID: %+R011 C0 3$        9    36
    99.50       97.82                              ID: %+R011 C0 4$        9    36
   111.27      110.42                              ID: %+R011 C0 9$        9    36
   106.30      105.33                              ID: %+R011 C010$        9    36
```

Figure B5-1: Listing of Output From Sample DBA Input Data Cards

APPENDIX B-6

PROGRAM NEWCITY

```
RM3,STCSA,CM55000,T30,I060. P720119 MCGREGOR 55421
FTN,R=3.
MAP,PART.
ATTACH,CCAUX,CCAUX,ID=X654321.
ATTACH,CC6600,ID=X654321.
LIBRARY,CCAUX,CC6600.
LGO.
"  END OF RECORD
      PROGRAM NEWCITY (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PLOT)
C
C     PROGRAM NEWCITY IS DESIGNED TO PLOT SPL VS. HORSEPOWER AND THRUST
C     FOR ANY PROPELLER RUNS.  THE USER MAY SPECIFY THE USE OF ONLY
C    PART OF THE DATA FOR PLOTTING AND MAY RECEIVE THE DATA IN EITHER DB
C     OR DBA.  CURVES MAY BE EITHER SPLINE FITTED OR UP TO SIXTH ORDER
C     POLYNOMIAL FITTED.  NAMELISTED PARAMETERS ARE LISTED BELOW ALONG
C     WITH INSTRUCTIONS FOR THEIR CHANGE.
C
C ** DATA TO BE READ IN
C    SPECIFICATION OF NUMBER OF RPM VALUES IN RUN
C        NRPM = RPM VALUES PER RUN
C
C    SPECIFICATION OF MICROPHONES IN DATA
C        NMIKE=NUMBER OF MIKES
C        IDMIKE=MICROPHONE IDENTIFICATION NUMBERS
C
C ****   PRESET PARAMETERS (NAMELIST)
C
C        NCURVE = (0) .. SPLINE-FIT
C                 1 THRU 6 .. NTH ORDER POLYNOMIAL FIT
C
C        IOPLOT =  1  .. HORSEPOWER ONLY
C                  2  .. THRUST ONLY
C                 (3) .. BOTH
C
C        LEGEND = (1) .. LEGEND BLOCK PRINTED
C                  0  .. BLOCK OMITTED
C
C        IORPM = (1) .. ALL AVAILABLE DATA USED IN PLOTS
C                 2  .. 3 RPM VALUES PLOTTED REGARDLESS OF DATA INPUT
C
C        IODBA = (0) .. OUTPUT IN DB
C                 1  .. OUTPUT IN DBA
C
C        YMIN =   (40.) .. MINIMUM DB OR DBA FOR PLOT
C        YMAX = (120.) .. MAXIMUM DB OR DBA FOR PLOT
C
C        XMINT =      (0.) .. MINIMUM THRUST FOR PLOT
C        XMAXT = (1625.) .. MAXIMUM THRUST FOR PLOT
C
C        XMINH =    (0.) .. MINIMUM HORSEPOWER FOR PLOT
C        XMAXH = (260.) .. MAXIMUM HORSEPOWER FOR PLOT
C
C      * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C        NAMELIST FORMAT  (EXAMPLE: $INPUT NCURVE=2, XMINT=40.$
C
      INTEGER HEAD
```

```
      DIMENSION HEAD(5), X(2,3,5), Y(4,3,5), XMIKE(10), LMIKE(4), TITLEX
     1(2,2), TITLEY(4), TPLBL1(2), BETA(3), XSTEP(2), XDAT(7), YDAT(7),
     2IDMIKE(10), CX(103), CY(103), W(5), WORK(100), COEF(7), ORD(6),
     3XMIN(2)
      NAMELIST/INPUT/ NCURVE,IOPLOT,LEGEND,IORPM,IODBA,YMIN,YMAX,XMINT,
     1XMINH,XMAXT,XMAXH
      DATA TITLEY/10HSOUND LEVE,10HLS IN DB R,10HE 0.0002 M,10HICROBAR
     1 /,(TITLEX(1,I),I=1,2)/10H      HORSE,10H    THRUST/,(TITLEX(2,I),I
     2=1,2)/10HPOWER     ,10H (LBS)     /,TPLBL1/10HMIKE NUMBE,10HR
     3   /,                     ORD/3H1ST,3H2ND,3H3RD,3H4TH,3H5TH,3H6TH/
C     MOVE PEN TO NEW ORIGIN
      CALL PLOT (0.,1.,-3)
      NCURVE=0 $ IOPLOT=3 $ LEGEND=1 $ IORPM=1 $ IODBA=0 $ YMIN=40.
      YMAX=120. $ XMINT=0. $ XMINH=0. $ XMAXT=1625. $ XMAXH=260.
    1 READ (5,INPUT)
      READ (5,28) NRPM
      READ (5,28) NMIKE
      READ (5,29) (IDMIKE(JJ),JJ=1,NMIKE)
      NLINE=1
      IF (NCURVE.NE.0) NLINE=-1
      DO 2 JJ=1,NMIKE
    2 XMIKE(JJ)=FLOAT(IDMIKE(JJ))
      YSTEP=(YMAX-YMIN)/8.0
      XSTEP(1)=(XMAXH-XMINH)/6.5
      XSTEP(2)=(XMAXT-XMINT)/6.5
      XMIN(1)=XMINH
      XMIN(2)=XMINT
C **  READ IN HORSEPOWER AND THRUST VALUES
    3 CALL READER (HEAD,BETA,X,Y,NRPM,NMIKE,IORPM,NSIZ,IODBA)
      SUMMA=0.0
      LIND=0
      IF (HEAD(1).EQ.10H          ) GO TO 27
      IF (HEAD(1).EQ.10HRESTART   ) GO TO 1
      IF (IOPLOT.NE.1.AND.IOPLOT.NE.2) GO TO 4
      LIND=1
      L=IOPLOT
      GO TO 5
    4 CONTINUE
      L=1
    5 CONTINUE
    6 DO 26 I=1,NMIKE
C **  DRAW AXIS AND LABELS
      IF (IODBA.EQ.1) GO TO 7
      CALL AXIS (0.,0.,TITLEY,40,8.,90.,YMIN,YSTEP)
      GO TO 8
    7 CALL AXIS (0.,0.,38HSOUND LEVELS IN DBA RE 0.0002 MICROBAR,38,8.,9
     10.,40.,10.)
    8 CALL AXIS (0.,0.,TITLEX(1,L),-20,6.5,0.,XMIN(L),XSTEP(L))
      CALL SYMBOL (2.25,8.4,0.15,TPLBL1,0.,20)
      CALL NUMBER (4.05,8.4,0.15,XMIKE(I),0.,-1)
      CALL SYMBOL (0.85,8.25,0.1,HEAD,0.,50)
      IP=0
C **  DRAW CONSTANT BLADE ANGLE CURVES
    9 IJ=1
      JPOINT=NLINE
      IND=0
```

```
      J=1
   10 CONTINUE
      DO 11 K=1,NSIZ
      YDAT(K)=Y(I,J,K)
   11 XDAT(K)=X(L,J,K)
C ** SKIP 5 DEGREE DUMMY DATA LINES (= 40. DB/DBA)
      TOT=TOTAL(YDAT,NSIZ)
      CUTOFF=40.0*FLOAT(NSIZ)
      IF (TOT.LE.CUTOFF) GO TO 23
      JK=J
      GO TO 15
C ** DRAW CONSTANT RPM CURVES
   12 IJ=2
      JPOINT=0
      IND=1
      K=1
   13 CONTINUE
      DO 14 JJ=1,3
      YDAT(JJ)=Y(I,JJ,K)
   14 XDAT(JJ)=X(L,JJ,K)
C ** SKIP ANY DUMMY LINES
      TOT=TOTAL(YDAT,3)
      IF (TOT.LE.120.0) GO TO 23
      JUMP=3
      JK=K
      GO TO 16
   15 ISYM=J-1
      JUMP=NSIZ
   16 XDAT(JUMP+1)=XMIN(L)
      XDAT(JUMP+2)=XSTEP(L)
      YDAT(JUMP+1)=YMIN
      YDAT(JUMP+2)=YSTEP
C ** REMOVE 5 DEGREE DUMMY DATA POINTS
      IF (YDAT(2).GT.40.0) GO TO 18
      MOVE=JUMP+1
      DO 17 KI=2,MOVE
      XDAT(KI)=XDAT(KI+1)
   17 YDAT(KI)=YDAT(KI+1)
      XDAT(MOVE+1)=0.0
      YDAT(MOVE+1)=0.0
      JUMP=JUMP-1
C     DRAW FITTED CURVE AND/OR DATA POINTS
   18 IF(JPOINT.EQ.0.AND.IJ.EQ.2) GO TO 19
      CALL FLINE (XDAT,YDAT,-JUMP,1,JPOINT,ISYM)
      YLOC=0.8-(.15*FLOAT(ISYM))
      IF (LEGEND.EQ.0.OR.IJ.EQ.2) GO TO 19
C     DRAW LEGEND BLOCK FOR PARTICULAR LINE
      CALL SYMBOL (4.20,YLOC,0.1,22H--     DEG. BLADE ANGLE,0.,22)
      CALL SYMBOL (4.0,(YLOC+.05),0.1,ISYM,0.,-1)
      CALL NUMBER (4.5,YLOC,0.1,BETA(JK),0.,-1)
   19 IF (NCURVE.EQ.0) GO TO 23
C     CALCULATE AND DRAW LEAST SQUARES FITTED CURVE
      DO 20 II=1,JUMP
      CX(II)=XDAT(II)
   20 CY(II)=YDAT(II)
      STEP=(CX(JUMP)-CX(1))/100.
```

```
      NCP=NCURVE
      ICPR=NCURVE+1
      IF(JUMP.LT.ICPR) NCP=JUMP-1
      PRINT *,"PASS ",J," THROUGH PLSCF"
      CALL PLSCF (CX,CY,-1,JUMP,NCP,NMAX,COEF,0,XD,XO,WORK,IER)
      PRINT *, "NCP = ",NCP,"     ERROR NUMBER = ",IER,"     NMAX = ",NMAX
      PRINT *,"COEFS = ",(COEF(KK),KK=1,7)
      LUPEND=NMAX+1
      DO 22 JJ=1,101
      CX(JJ+1)=CX(JJ)+STEP
      DO 21 KK=1,LUPEND
   21 SUMMA=SUMMA+(COEF(KK)*(CX(JJ)**(KK-1)))
      CY(JJ)=SUMMA
   22 SUMMA=0.0
      CX(102)=XMIN(L)
      CX(103)=XSTEP(L)
      CY(102)=YMIN
      CY(103)=YSTEP
      PRINT *,(CX(KK),KK=1,103)
      PRINT *,(CY(KK),KK=1,103)
      CALL LINE (CX,CY,101,1,0,ISYM)
      PRINT *,"LINE DRAWING COMPLETED"
      PRINT *, " "
      IF(NCURVE.EQ.0.OR.IP.EQ.1) GO TO 23
      CALL SYMBOL (2.6,0.1,0.10,37H**      ORDER POLYNOMIAL FITTED CURVES
     1,0.,37)
      CALL SYMBOL (2.9,0.1,0.1,ORD(NCP),0.,3)
      IP=1
   23 CONTINUE
      IF (IND.EQ.1) GO TO 24
      J=J+1
      IF (J.LE.3) GO TO 10
      GO TO 25
   24 CONTINUE
      K=K+1
      IF (K.LE.NSIZ) GO TO 13
   25 CONTINUE
      IF (IJ.EQ.1) GO TO 12
C     MOVE PEN TO NEW ORIGIN
   26 CALL PLOT (8.5,0.,-3)
      IF (LIND.EQ.1) GO TO 3
      L=L+1
      LIND=1
      GO TO 5
   27 CONTINUE
      CALL PLOTE
      STOP
C
   28 FORMAT (I5)
   29 FORMAT (10I5)
      END
```

BEST AVAILABLE COPY

```
      SUBROUTINE READER (HEAD,BETA,X,Y,NRPM,NMIKE,IORPM,NSIZ,IODBA)
      DIMENSION HEAD(5), X(2,3,5), Y(4,3,5), BETA(3)
      INTEGER HEAD
      READ (5,14) HEAD
      IF (HEAD(1).EQ.10H          .OR.HEAD(1).EQ.10HRESTART   ) GO TO 13
      IF (IORPM.EQ.1) GO TO 9
      IF (IORPM.EQ.2.AND.NRPM.EQ.3) GO TO 9
C ** READ 3 POINTS IF 5 ARE AVAILABLE
      DO 2 I=1,3
      READ (5,15) BETA(I)
      DO 1 J=1,2
      READ (5,16) RPM,X(1,I,J),X(2,I,J)
    1 READ (5,17) TRASH
    2 READ (5,16) RPM,X(1,I,3),X(2,I,3)
      IF (IODBA.EQ.1) GO TO 5
C ** READ DB DATA
      DO 4 I=1,NMIKE
      DO 4 J=1,3
      DO 3 K=1,2
      READ (5,17) Y(I,J,K)
    3 READ (5,17) TRASH
    4 READ (5,17) Y(I,J,3)
      GO TO 8
C ** READ DBA DATA
    5 DO 7 I=1,NMIKE
      DO 7 J=1,3
      DO 6 K=1,2
      READ (5,18) Y(I,J,K)
    6 READ (5,18) TRASH
    7 READ (5,18) Y(I,J,3)
    8 NSIZ=3
      GO TO 13
C ** READ ALL AVAILABLE DATA
    9 DO 10 I=1,3
      READ (5,15) BETA(I)
      DO 10 J=1,NRPM
   10 READ (5,16) RPM,X(1,I,J),X(2,I,J)
      DO 12 I=1,NMIKE
      DO 12 J=1,3
      DO 12 K=1,NRPM
      IF (IODBA.EQ.1) GO TO 11
C ** READ DB DATA
      READ (5,17) Y(I,J,K)
      GO TO 12
C ** READ DBA DATA
   11 READ (5,18) Y(I,J,K)
   12 CONTINUE
      NSIZ=NRPM
   13 RETURN
C
   14 FORMAT (8A10)
   15 FORMAT (30X,F10.3)
   16 FORMAT (3F10.3)
   17 FORMAT (F10.3)
   18 FORMAT (10X,F10.3)
      END
```